The Significance of Rubbish Tips as an Additional Food Source for the Kelp Gull and the Pacific Gull in Tasmania

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CONTENTS

ABSTRACT

Many species of gull have exhibited dramatic population increases, particularly in the Northern Hemisphere, in response to protection and to an increased supply of food provided by human activities. Population increases have been manifested by higher population densities as well as increases in range and the formation of new breeding colonies. This growth has had a number of adverse environmental effects: gulls have disadvantaged other bird species and have become agricultural pests, public health risks, urban nuisances and aviation hazards.

In Australia, the small Silver Gull (*Larus novaehollandiae*) has displayed a similar pattern of population growth. By contrast, the large endemic Pacific Gull (*Larus pacificus*) has experienced a reduction in range. A second large species, the Kelp Gull (*Larus dominicanus*) has a circumaustral distribution; it has recently become established in Australia and is most numerous in south-east Tasmania. A review of the biology of the Pacific Gull and the Kelp Gull indicates that the two species have similar requirements and could be expected to compete for resources.

This study examined the nature and extent of competition for food, with particular reference to the significance of rubbish tips as a food source for the two species. Gull numbers were monitored at 11 tips in northern Tasmania and 17 tips in south-east Tasmania during winter of 1981. Regular monitoring and detailed behavioural observations were conducted at three large tips and a number of representative shoreline feeding sites in the Hobart area.

Tips were found to be an important food source for Kelp Gulls in Tasmania, and have probably contributed to their population growth. Pacific Gulls also utilize tips but to a lesser extent. Numbers of Pacific and Kelp Gulls were highly correlated with the human population served by the tips, but no relationship was detected between gull numbers and the distance of the tips from water. Numbers of gulls at tips were highest in June and July then generally declined, but exhibited wide fluctuations which were not strongly correlated with any of nine meteorological and tidal variables.

Pacific Gulls of all ages were dominant over Kelp Gulls in overt competition for food. Pacific Gulls utilized a predominantly kleptoparasitic strategy at tips while Kelp Gulls tended to forage steadily,

but overall the two species had equivalent feeding efficiencies. In general, Kelp Gulls showed a preference to feed at rubbish tips, whereas Pacific Gulls preferred shoreline sites. At some shoreline feeding sites adult Pacific Gulls defended winter feeding territories singly or in pairs against Kelp Gulls and immature Pacific Gulls. There was also no clear evidence that the Pacific Gull has suffered a population decline since the arrival of the Kelp Gull in south-east Tasmania, and the degree of resource partitioning shown by the two species indicates that they are not competing closely for food. However, competition for nest sites on the breeding islands has not been fully studied.

Continued growth of the Kelp Gull population in Tasmania is likely, and potential environmental problems are apparent. A range of control measures is available, but control does not appear to be necessary at present. Management of the Kelp Gull and the Pacific Gull in the future will require periodic population monitoring and a comprehensive breeding study to examine the relationships between the two species in mixed colonies.

1
Introduction

1. INTRODUCTION

Human activity has had a profound effect on many wildlife species. There has been a dramatic acceleration in the rate of extinction in historic times, and many more species have suffered a reduction in numbers and range. These changes rarely have a single cause, but the most common pressures created by human activity are loss of habitat, hunting, pollution and competition with introduced species (Fisher, 1971). Less often, human activities have the opposite effect and a species undergoes an increase in population size and distribution. One of the most spectacular changes of this type has been achieved by gulls.

Gulls as a group are adaptable and opportunistic scavengers. They are thus well suited to exploit the food provided by humans in such forms as garbage and offal, and it is generally agreed that the enormous volumes of these types of food have enabled gulls to build up to very high population levels, often with serious environmental consequences (Graham, 1975a). These changes have been most marked and best documented in the Northern Hemisphere, particularly in Great Britain and the United States.

In Australia the small Silver Gull (*Larus novaehollandiae*) has followed this general pattern (e.g. Sharland, 1956). However, the only other species, the large endemic Pacific Gull (*Larus pacificus*), is unusual in that it has suffered a reduction in its historic range and is common only in parts of its present distribution (Serventy *et al.*, 1971).

During this century a similar species of large gull, the Kelp Gull (*Larus dominicanus*), has reached Australia and established a breeding population. It is a Southern Hemisphere species which occurs in South Africa, South America, the sub-antarctic islands, the Antarctic continent, New Zealand and now Australia (Serventy *et al.*, 1971). It is closely related to the Herring Gull (*Larus argentatus*) and the Lesser Black-backed Gull (*Larus fuscus*) which have been so successful in the Northern Hemisphere (Moynihan, 1959) and it has shown the same propensity for population growth. Although it is known to breed in three areas of Australia, the Kelp Gull has displayed by far its most rapid growth in south-east Tasmania (Thomas, 1969).

The Pacific Gull and Kelp Gull are similar in size and morphology, so it could be predicted that they would compete for resources such as food or nest sites. In the Hobart area large flocks of Kelp Gulls were known to feed on rubbish tips, particularly in winter, but the Pacific Gull occurred in far lower numbers at tips and appeared to be less inclined to feed at them. It was felt by local ornithologists that this difference in behaviour would disproportionately enhance the survival of Kelp Gulls, and that the Pacific Gull population would decline in consequence. The aim of this study was to examine the significance of rubbish tips as an additional food resource for the two species. To fulfil this aim, the study had a number of specific objectives.

(a) An examination of the phenomena of gull population growth in the Northern Hemisphere.

This involved a literature survey covering the causes, mechanisms and effects of population growth and the likely trends in the future, to indicate the possible course of population change in Australian gulls.

(b) A review of the current biological knowledge of gulls in Australia, with particular reference to the Pacific Gull and the Kelp Gull.

The lack of any comprehensive ecological study of the Pacific Gull necessitated the compilation of a number of isolated references and unpublished observations. By contrast, the Kelp Gull has been more thoroughly researched, but ecological studies conducted throughout its range have not previously been reviewed in detail.

(c) A field study of the feeding behaviour of Kelp and Pacific Gulls in an attempt to determine the role of rubbish tips as an additional food source.

Due to limitations of time this work had to be restricted to the period of winter and early spring. Three approaches were taken.

i) Rubbish tips were surveyed to determine the numbers of Kelp and Pacific Gulls feeding at them, and the behavioural interactions and feeding strategies exhibited by both species were studied. This work was concentrated on south-east Tasmania where the two species are sympatric, but some tips were surveyed in the north of the state where Pacific Gulls fed in the absence of Kelp Gulls.

ii) A sample of relatively natural feeding sites in south-east Tasmania was surveyed to compare usage of these sites by the two species.

iii) An attempt was made to capture and mark individual birds at tips so that their movements could be monitored and the degree of dependence on tips could be assessed. A drop net, a cannon net and a cage trap were tried as methods of capturing gulls without success in the limited time available. Attempts to mark birds directly with a paint-pellet gun were also unsuccessful and were found to disrupt the ongoing monitoring programme. This aspect of the study had to be abandoned.

(c) An examination of the methods available for the management of the two species, with particular reference to control measures which have been applied to pest populations of gulls. Alternative techniques of rubbish disposal were included as methods of modifying gull habitats.

An obvious area of potential competition between Kelp Gulls and Pacific Gulls is on the breeding islands. Pacific Gulls also breed on the three main breeding islands for Kelp Gulls, and some observers (Green, 1977; Fletcher *et al.*, 1980) have suggested that there was competition for nest sites and Pacific Gulls were being forced out of these colonies. It was not possible to examine this suggestion as part of the field programme because time constraints limited work to the winter period. However, we collaborated in a preliminary study of colony formation and nest success on Green Island during the preparation of this thesis. The findings of that study will be presented in a separate report (Coulson *et al.*, in preparation).

2
Gull Populations in the Northern Hemisphere

2. GULL POPULATIONS IN THE NORTHERN HEMISPHERE

Of the world total of 44 species of gull, 34 are found solely or predominantly in the Northern Hemisphere (Tuck, 1980). As a group, northern gulls are conspicuous because of their high population densities, and their habit of frequenting areas populated by humans. Most of the 34 species are apparently thriving. A notable exception is Audouin's Gull (*Larus audouinii*) which has a total population of only about 1600 pairs (Mayol, 1980). This species is listed as rare in the Red Data Book by the International Union for Conservation of Nature and Natural Resources (1979).

Historically, other species of gull at present relatively numerous have also been reduced to very low populations. For example, Harrisson and Hurrell (1933) considered the Great Black-backed Gull (*Larus marinus*) to be very near extinction in 1900, when there were only 20 pairs known in England and Wales. Since then, this species has shown a marked increase in numbers. This growth in population has been paralleled in many other species of gull, and this phenomenon is investigated in this chapter. Localities referred to in this chapter are shown in Figure 2.1.

2.1 Population Increases

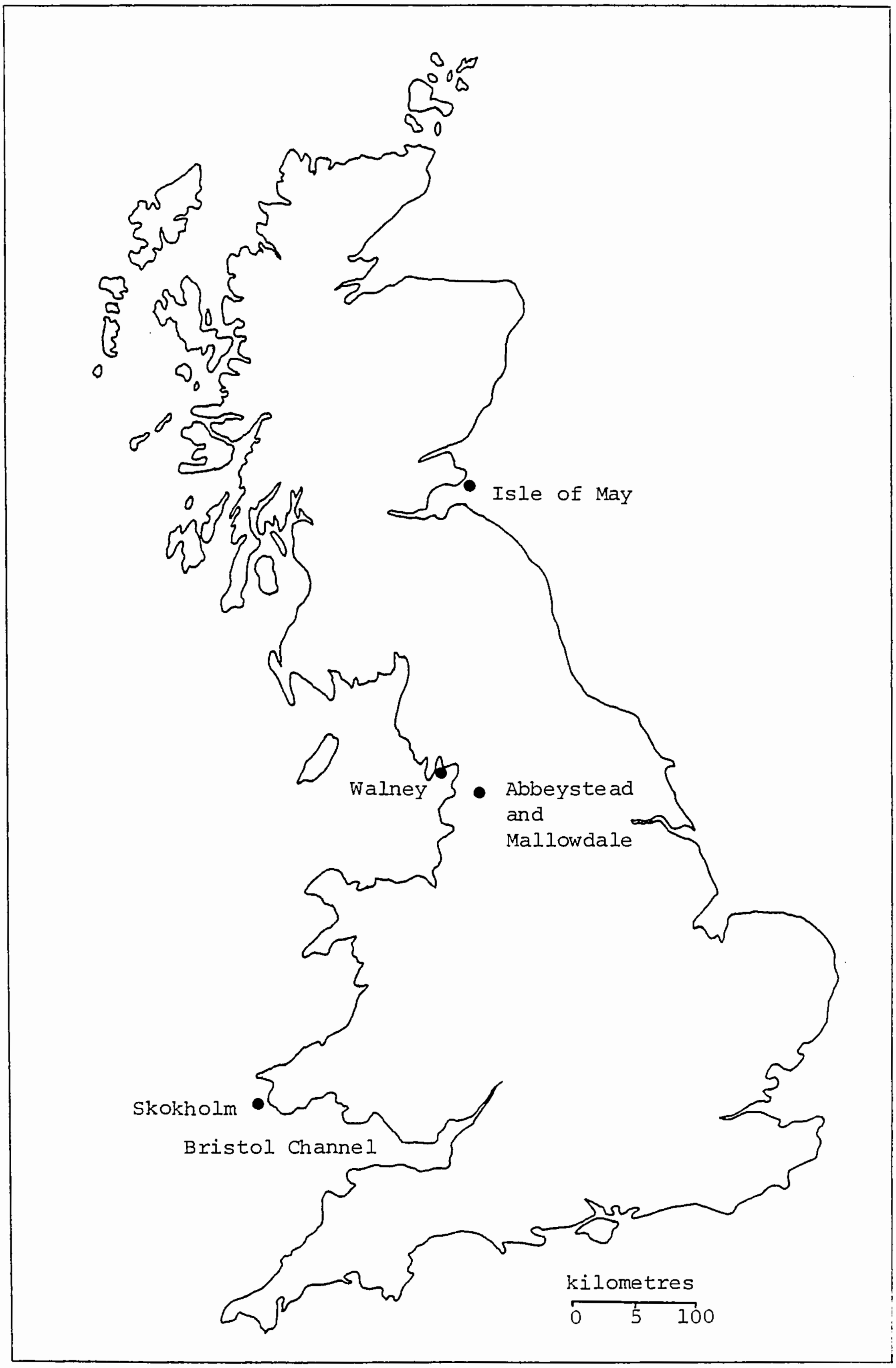
Increases in gull populations have apparently been widespread in the Northern Hemisphere. Kumari (1975) noted great increases in the numbers of gulls in the basin of the Baltic Sea, and Harris (1970) recorded dramatic population increases by the Herring Gull (*Larus argentatus*) in Holland and North Germany as did Kilpi *et al.* (1980) in Finland. However, population changes in the Northern Hemisphere have been best documented in eastern North America and the British Isles.

As well as being widespread geographically, population increases have occurred in a wide spectrum of both smaller and larger gull species. Smaller gulls are defined here as those measuring less than 50 cm in length.

Three smaller gulls listed by Parslow (1967) as having increased this century are the Common Gull (*Larus canus*), the Black-headed Gull (*Larus ridibundus*) and the Kittiwake (*Rissa tridactyla*). However, it is the

FIGURE 2.1

Location of Gull Colonies in the British Isles
Referred to in Chapter 2



larger gulls (more than 50 cm in length), especially the Herring Gull (*Larus argentatus*), Lesser Black-backed Gull (*Larus fuscus*), and Great Black-backed Gull (*Larus marinus*), which will be considered in most detail in this section. This is partly because of the more intensive studies which have been carried out on the larger gulls, but also because they are more ecologically analogous to the Pacific and Kelp Gulls of the Southern Hemisphere which are our principal concern in this project.

2.1.1 Population Size and Rates of Change

(a) The British Isles

Information on population levels and rates of increase for the five best documented British colonies is summarised in Table 2.1. Increases in populations of both Herring and Lesser Black-backed Gulls have occurred at all of these colonies but whereas the Isle of May and Bristol Channel colonies have apparently grown steadily since the turn of the century, the rate of population growth at Walney and Skokholm colonies increased markedly after around 1950.

The colony at Abbeystead and Mallowdale estates in Lancashire to some extent followed the pattern of increase at Walney and Skokholm colonies but differs from the other colonies listed in Table 2.1 by being inland, and having shown more rapid rates of growth. The late date of establishment of the colony (1938 for Lesser Black-backed Gulls and 1949 for Herring Gulls) coincides with the widespread trend to inland nesting noted in Section 2.1.2.

The rates of increase shown in Table 2.1 for coastal colonies of Herring Gulls are in keeping with an overall 12.8% annual increase since 1930 for Herring Gulls in the British Isles (Chabrzyk and Coulson, 1976). Coulson and Monaghan (1978) quote a similar figure, saying that the population of Herring Gulls in Britain has been increasing at 13% each year since about 1945, with about 750,000 pairs nesting there in 1976.

Great Black-backed Gulls have not been studied in individual colonies to the same extent as Herring and Lesser Black-backed Gulls. However, overall increases have been noted in this species. In England and Wales, numbers rose markedly from near extinction in 1900 to about 1,000 pairs

TABLE 2.1

Population Levels and Rates of Increase Reported for Herring and Lesser Black-backed Gulls at Five Colonies in Britain

Colony	Time Period	Herring Gull		Lesser Black-backed Gull	
		Annual Rate of Increase	Breeding Pairs at End of Period	Annual Rate of Increase	Breeding Pairs at End of Period
Isle of May[a] (Scotland)	1907 - 1972	13%	16,700	13%	1,700
Walney (Lancashire)	1920s-1950[b]	gradual	180	gradual	520
	1950 - 1965[b]	"population explosion"	9,250	"population explosion"	9,250
	1969[c]		17,500		17,500
Skokholm[d]	1928 - 1940	gradual	300	gradual	800
	1965 - 1969	about 10%	1,350	nearly 20%	2,000
Bristol Channel[e]	1900 - 1975	10.1%	16,486	9.1%	5,017
Abbeystead and Mallowdale [f] (inland Lancashire)	1938 - 1956	-	-	gradual	1,000
	1956 - 1965	30%	2,800	36%	16,000
	1965 - 1975			0	16,000

a - Duncan, 1978. Although Herring Gulls were first recorded breeding on the Isle of May in 1907, Lesser Black-backed Gulls did not breed there until 1930.

b - Brown, 1967a.

c - MacRoberts and MacRoberts, 1972.

d - Harris, 1970. This population of Lesser Black-backed Gulls declined in the period 1940-1949, and Harris attributed this to intensive egg collecting.

e - Mudge, 1981.

f - Duncan, 1981. Numbers of Lesser Black-backed Gulls apparently stable since 1965.

in 1930. Between 1930 and 1956 an almost threefold increase occurred in some island populations, while mainland colonies remained largely stable (Parslow, 1967). Beaman (1978) placed the overall growth rate at around 3% per annum for later surveys (up to 1969-70), although some colonies continued to increase rapidly. The limited historical records available from northern Scotland, which contains about two-thirds of the British and Irish breeding populations of Great Black-backed Gulls, suggest that patterns of growth there were similar to those which occurred in England and Wales (Beaman, 1978). Parslow (1967) reported that Irish colonies of this species were smaller than those in Scotland, but apparently also increasing.

(b) North America

Increases in populations of Herring and Great Black-backed Gulls in the New England region of the United States of America were described by Gross (1955) as "phenomenal". The Lesser Black-backed Gull, the third British species considered in detail, is not found in North America. While growth in individual colonies of Herring Gulls may have been very rapid, the overall increase of this species appears to have been considerably slower than that documented in Britain. The New England Herring Gull population increased from 4 000 to 120 000 breeding pairs in the 65 years from 1900 (Kadlec and Drury, 1968). According to Drury and Kadlec (1974), this represents an average annual increase of 4.5-5.0%, which probably declined to about 1% in the years from 1951 to 1973, indicating that the population was stabilizing in New England. However, Herring Gull numbers continue to increase rapidly in more southerly colonies (Nisbet, 1978).

Great Black-backed Gulls increased at a faster rate than Herring Gulls. First recorded nesting in the United States of America in 1926, they had increased to about 12 000 breeding pairs by 1965, thus showing an average rate of increase of over 17% per annum. By 1976, the population was still increasing, and had increased to 15 000 pairs. The total North American population of Great Black-backed Gulls would be at least twice this figure, since numbers in Nova Scotia and Newfoundland have not been surveyed fully but are higher than those in the United States (Nisbet, 1978).

2.1.2 Growth of Breeding Colonies

Within the existing breeding range of a species, local population increases may occur by means of the growth of established colonies, or by the formation of new colonies. New colonies will also be formed when increases involve an extension of breeding range.

A general pattern of colony growth through increased nesting density with relatively little expansion into adjacent unoccupied areas was described as typical of most of the growing North Atlantic gulleries by MacRoberts and MacRoberts (1972). These workers found that increased nesting density accounted for most of the population growth at Walney colony between 1965 and 1969, as did Davis and Dunn (1976) at Skokholm colony. These findings are in keeping with a model of Herring Gull colony growth proposed by Chabrzyk and Coulson (1976), in which areas of high nest density were most attractive to prospective breeding birds.

The same model indicates that there is an upper limit to nesting density, beyond which the rate of recruitment of breeding birds is less than the adult mortality rate. Beyond this point, the number of nesting pairs in a colony can only increase if the area of the colony is expanded. When all available space has been fully utilized, further population growth will necessarily involve the formation of new colonies.

(a) Growth of existing colonies

The number of gulls breeding in a colony will increase when the rate of recruitment into the breeding population exceeds the average mortality rate of the breeding birds. Chabrzyk and Coulson (1976) showed that breeding adult gulls were extremely faithful to the colony in which they had previously bred. In the case of a closed colony, recruitment occurs "from within" when birds born in the colony reach maturity and begin to breed. Immigration of birds born in other colonies may also add to the numbers recruited into the breeding population of a colony.

Theoretical calculations, using available parameters of survival and reproductive potential, indicated that the rates of increase observed on both Skokholm and Bristol Channel colonies (see Table 2.1) could be achieved by closed breeding populations (Harris, 1970; Mudge, 1978). Harris (1970) attributed the 20% rate of increase in Lesser Black-backed Gulls on Skokholm to their very high fledging success. Both authors considered that evidence from banding of gulls also supported the concept of natural increase without immigration.

Elsewhere, immigration has been involved in some gull population growth. Nisbet (1978) stated that the rapid increase (over 17% per annum) in the total breeding population of Great Black-backed Gulls in the United States was aided by immigration from Canada.

After analyzing the rate of population growth at Walney colony (27% per annum) Brown (1967a) concluded that the sharp increase in that gull population could not be accounted for without allowing for a massive immigration in the early 1950's. Duncan (1981) also implicated immigration in accounting for the high rates of increase at the Abbeystead and Mallowdale colony. He noted that several Lesser Black-backed Gulls recovered in the colony had been banded as chicks elsewhere, mainly at Walney which is the other principal colony of this species.

Considerable dispersal of young gulls was noted by Chabrzyk and Coulson (1976). Although breeding adult gulls show almost complete attachment to the colony and area in which they have previously bred, about 65% of surviving young Herring Gulls fledged on the Isle of May did not breed on their natal colony. Birds reared in the Isle of May colony were found breeding up to 250 km away. Approximately equal numbers of gulls apparently came from elsewhere to breed on the Isle of May as emigrated from the colony, so that the movement of young birds did not greatly affect the overall population dynamics of the colony and the observed annual increase of 13% was equal to that predicted from the fledging success rate on the colony.

The net effect of migration on this colony was zero, but the important finding that many young birds do move away from their natal colonies provides a basic source of birds which could contribute to a net immigration into another existing colony, or to the formation of a new colony.

(b) Formation of new colonies

A pattern of new colony formation is clearly shown in the history of the increase of both Herring and Great Black-backed Gulls on the eastern coast of the United States of America (Gross, 1955; Kadlec and Drury, 1968;

Drury and Kadlec, 1974; Drury, 1973; Nisbet, 1978). In 1900 there were about 10 000 pairs of Herring Gulls in 17 colonies; by 1965 there were about 90 000 pairs in over 300 colonies. The colonization of new islands accompanied the progressive southward spread of the gulls, and Nisbet (1978) traced a wave of rapid growth; from Maine in the 1920's and 1930's, to Massachusetts in the next two decades, to Long Island in the 1960's and early 1970's, to the southernmost colonies in Maryland, Virginia and North Carolina.

Linear extension of breeding range was less obvious in Britain. Most of the colonies listed in Table 2.1 were established in the early part of this century, as indicated by the initial dates shown in that table, and Herring Gulls at least appear to have increased at a fairly uniform rate simultaneously throughout Britain (Chabrzyk and Coulson, 1976). Even so, new colonies have formed within the overall breeding range. For example, Mudge (1978) noted that there was only one known Herring Gull breeding site in the Bristol Channel in 1901, but that numerous other colonies had since been formed, both on islands and on the mainland. Harrisson and Hurrell (1933) and Parslow (1967) recorded that the number of Great Black-backed Gull colonies increased simultaneously with the population growth of this species in the British Isles.

More noticeable than the formation of new colonies in traditional situations has been the utilization of different nesting habitats.

Parslow (1967) wrote that nesting by Herring Gulls on buildings was almost unknown prior to 1940, "but in the 1940's and 1950's this became an established habit on the roofs of houses and factories in many seaside towns". Roof top nesting by gulls in Britain has since spread and increased. For example, the proportions of Herring Gulls in the Yorkshire area nesting on buildings increased from 3% of the total in 1969-1970 to 12% in 1978-1979 (Mericas Leach *et al.*, 1980). Surveys throughout Britain were conducted in 1969 and 1976. The results of these surveys were discussed by Monaghan and Coulson (1977), and Coulson and Monaghan (1978), and are summarised in Table 2.2. Not only had the colonies surveyed in 1969 increased in size, but many new areas were colonized.

TABLE 2.2

Rate of Increase in Nesting by Herring and Lesser Black-backed Gulls on Rooftops in Britain, 1969-1976. From Monaghan and Coulson (1977)

	Herring Gulls	Lesser Black-backed Gulls
Increase in number of breeding pairs in colonies in existence in 1969	13% p.a.	24% p.a.
Increase in number of colonies	9.3% p.a.	13% p.a.
Increase in total number of breeding pairs in rooftop colonies	17% p.a.	28% p.a.

Urban nesting gulls are predominantly Herring Gulls (Monaghan and Coulson, 1977), but as shown in Table 2.2, the number of Lesser Black-backed Gulls breeding on rooftops has been increasing at a greater rate. The number of Great Black-backed Gulls recorded nesting in towns was very low but had also increased, from a single pair in 1970 to seven pairs in 1974.

Several factors appear to have contributed to the high rates of increase observed in urban colonies. The discovery that several birds breeding on rooftops in northeast England had been banded as chicks on the Isle of May colony, and the fact that the fastest growing urban colonies were located near large natural colonies, prompted Monaghan and Coulson (1977) to propose high recruitment into rooftop colonies of young birds from saturated or near-saturated natural colonies. Further studies showed that survival of young was better in towns than in traditional nesting places. Monaghan (1979) found that the breeding success of Herring Gulls nesting on rooftops in an area of northeastern England averaged 1.2 - 1.6 chicks per pair, considerably higher than the figures of 0.6 - 1.2 recorded at more natural colonies. Since the breeding success on structurally isolated rooftop sites was almost double that on flat roofs where several pairs could nest together, Monaghan (1979) attributed the high success rate to the absence of cannibalism and lack of territorial aggression at the isolated sites. Survival of young birds after fledging may also be higher in towns. Bourne (1979) observed town-nesting Herring Gulls feeding young at the nest site right up until the next breeding season, compared with a maximum period of parental care in natural colonies of three to four months after fledging (Burger, 1981a). This behaviour would be expected to enhance survival of the juveniles during their first winter when high mortality of young birds usually occurs. Such prolonged parental care may be feasible because nests in towns are close to permanent food supplies such as garbage disposal areas (see Section 2.2).

Parslow (1967) noted the utilization of another non-traditional breeding habitat, in the increasing tendency throughout Britain and Ireland for gulls to nest inland. The trend to inland nesting was apparently widespread, since Kumari (1975) reported that previously maritime species (Common and Herring Gulls) had started to nest on inland waters in the Baltic Sea Basin. Inland colonies may assume considerable importance, as shown by the Abbeystead and Mallowdale gull colony in Lancashire (Table 2.1), which in 1974 contained about 25% of the entire British and Irish population of Lesser Black-backed Gulls. That colony is based on moorland, but nesting by Herring Gulls has also been recorded on ploughed fields and even on a concrete bus turning circle (King, 1981). Rooftop nesting has also extended to inland towns in recent years (Coulson and Monaghan, 1978).

The increase in inland nesting may be related to the increase in inland wintering of gulls noted by Kadlec and Drury (1968) and Hickling (1969, 1977). Recruitment of birds which found suitable breeding habitat during winter movements from other colonies could help to achieve the high rates of population growth noted at the Abbeystead and Mallowdale colony.

That gulls may take up nesting in their wintering areas has been suggested by Monaghan (1979) for town breeding birds in northeastern England, and by Drury and Kadlec (1974) as an explanation for the rapid growth of gull colonies on islands in southern New England.

Other different kinds of nesting habitat have been colonized as the North American breeding range extended southwards. Parnell and Soots (1975) recorded Herring Gulls and Great Black-backed Gulls breeding on man-made dredge islands in North Carolina, while Burger (1980) noted that Herring Gulls, which traditionally nest in dry areas, had adapted to nesting in salt marshes in New Jersey.

Another behavioural adaptation produced by the growth of gull populations may be the change noted by Baker (1980) in the usual winter migration of Lesser Black-backed Gulls. Adults of the species have been spending increasingly more of the winter in Britain, which Baker suggests may be a response to increasing competition for breeding territories.

2.2 Reasons for Population Increase

There seems to be general agreement with Murton's (1971) statement that the "enormous increases and range expansion of the gulls in recent years are without doubt primarily a result of man's activities". The two major facets of "man's activities" postulated by other writers as contributing to the gull population increases are protection of seabirds from human disturbance, and the provision of an improved food supply for gulls in the form of garbage and other waste.

2.2.1 Protection

In common with many other seabirds, gulls on both sides of the Atlantic suffered considerably from human interference during the closing decades of the nineteenth century. Collection of eggs was extensive at some colonies, while shooting of birds for sport and especially for the millinery trade eliminated or severely reduced many local gull populations. Graphic descriptions of the extent of this human predation in North America were provided by Graham (1975a), who also detailed the efforts of concerned individuals to gain protection of the birds and their breeding areas.

Once protection was afforded, the seabird population began to recover. Drury (1973) described the response of gulls in New England as "immediate and spectacular", and suggested that protection had "evidently been a major factor" associated with the increase of gulls in New England (Drury, 1974). A similar relationship between decline of human pressures and increase in gull population occurred in Great Britain (Davis, 1974; Monaghan and Coulson, 1977; Mudge, 1978) and in Holland (Spaans, 1971). Davis (1974) demonstrated that the effects of egg collection alone could be marked. Egg collection at Skokholm colony did not cease until after the Second World War, coinciding with the increase in the rate of growth in that colony (see Table 2.1). By contrast, the rate of increase on the Isle of May, where there had never been intensive egg collection, had been constant since the beginning of the twentieth century, and colonies where eggs were still collected intensively had not shown an increase in population.

The overall increases which followed protection allowed a return to earlier population levels. However, ancient population levels have since been exceeded, with gulls being apparently more numerous now than ever before. While reduction in human persecution is generally agreed to have been the initial cause of increase, the high levels reached were attributed to improved feeding conditions (e.g. Spaans, 1971; Mudge, 1978).

2.2.2 *Greater Food Availability*

Utilization of food sources provided by man is proposed by many authors as an important factor in the gull population "explosion".

There is some debate in the literature as to whether the supply of food has actually increased in parallel with the increase in gulls. Harris (1970) suggested that there may even have been a decrease in available food at Skokholm during the time of the greatest rate of gull increase at that colony. This led him to postulate a time lag between the increase in food and the increase in gulls, due to the gulls having to adjust their behaviour to exploit a new food supply. Similarly, when discussing the Walney colony, Brown (1967a) stated that "the food may have been there all the time, but the gulls might have only just learnt to exploit it fully".

This hypothesis is rejected by Davis (1974) who considered that such a delay would be inconsistent with the opportunism displayed by Herring Gulls; instead he proposed that the gulls on Skokholm were not able to realize the potential for increase presented by the improved food supply until the cessation of egg collection in that colony (see Section 2.2.1).

The main sources of food are garbage, sewage, fishing and agriculture. The importance of each source is examined in turn.

(a) Garbage. The most important "man-made" source of food for gulls is probably garbage.

Increases in human population would be expected to cause a corresponding rise in the amount of garbage produced. It has also been suggested (Davis, 1974) that the nutritional value of garbage may have risen as the human standard of living rose. The effects of changed waste disposal practices are less obvious. Harris (1970) considered that improved waste disposal facilities (together with a near constant local human population) may even have caused a decrease in the amount of garbage available to gulls. However, Davis (1974) and Mudge (1978) noted that changing disposal methods had tended to concentrate garbage at tips, making this food supply more accessible to gulls.

Feeding on garbage tips has been described as a factor contributing to gull increases in the United States of America (Kadlec and Drury, 1968; Hunt, 1972), Great Britain (e.g. Brown, 1967a; Davis, 1974), Holland (Spaans, 1971), Sweden (Kihlman and Larsson, 1974), and France (Isenmann, 1978). There is also indirect support for the notion that feeding on garbage supports high growth rates. The limitation of garbage during the Second World War was suggested by Drury (1973) as having been responsible for the decline in gull population growth in New England at that time. Hunt and Hunt (1976) studied Californian Western Gulls, which did not use rubbish but were dependent on schooling fish for adequate food for their young. The number of breeding pairs in the colony had not changed over 30 years, even though plenty of suitable nesting habitat remained, implying that the colony size was limited by food supply.

The mechanism by which tip feeding has allowed rapid population growth has been partly elucidated by studies which examined the feeding of young. Spaans (1971) found that chicks from broods fed garbage as well as natural food grew faster than chicks from comparable broods fed only natural foods, and postulated that more rapid growth of chicks would lead to higher fledging weight, which is associated with higher post-fledging survival. This is supported by the finding of Davis (1974) that the breeding success of birds utilizing garbage (1.0 young per pair) was considerably higher than others (0.3 young per pair), mainly due to better chick survival. Herring Gull colonies on outer islands in Maine had lower reproductive success than those closer in, which Kadlec and Drury (1968) suggested was due to the difference in accessibility of garbage from the different areas, with the outer islands representing a "natural" situation. Hunt (1972) found that the lower survival of chicks on islands distant from sources of edible refuse was due to parents on outer islands leaving their chicks for longer while foraging. Feeding on garbage thus appears to allow gulls to raise more chicks than is possible when only natural foods are utilized.

As well as being important during the breeding season, tip feeding may contribute to a high rate of population growth by enhancing survival of gulls, especially juveniles, during winter (Spaans, 1971, 1975; Davis, 1974; Graham, 1975b). Hickling (1969) cited the ready availability of food in tips as an important factor allowing the increase noted in inland wintering by gulls.

(b) Sewage

Sewage appears to be a less significant food source than garbage, although untreated sewage may be locally important. Fitzgerald and Coulson (1973) studied feeding of several species of gull along the tidal reaches of two rivers which received large quantities of untreated domestic and industrial wastes and concluded that the sewage was a staple source of food for Lesser and Great Black-backed Gulls, and to a lesser extent for the Herring Gull. Sewage treatment works were found by Fuller and Glue (1980) to be relatively unimportant for large gulls, being visited only in winter, by Herring Gulls.

(c) Fishing

Waste from the fishing industry has probably declined in importance as a food source for gulls, due to changed methods of handling fish; the increased trend to gutting fish at sea for freezing has reduced the tonnage of fish processed at docks (Harris, 1970; Davis, 1974).

Nevertheless, fish docks remained a valuable source of food for some gulls during the breeding season, and were regularly used by some apparently "specialist" feeding gulls which fed at the same position on the fish docks throughout the year (Davis, 1975).

Feeding in the vicinity of fishing boats may also yield a rich supply of food in the form of fish offal and rejected fish (Beaman, 1978).

(d) Agriculture

Harris (1965) noted that both Herring and Lesser Black-backed Gulls fed on arable land. Cultivation had increased in Britain, thus improving the food source for birds which "followed the plough", but with a corresponding reduction of permanent grassland which supplied food such as beetles and worms (Harris, 1970). Other agricultural sources of food are generated by intensive animal husbandry, such as the poultry farming mentioned by Brown (1967a) within the feeding range of Walney colony.

2.3 Effects of Population Increase

It is not surprising that the phenomenal increases in gull populations this century have caused problems. Of most concern to ornithologists are the effects of competition between rapidly increasing numbers of gulls and other seabird species. Problems are also encountered in areas closer to home for many people. "Habits as well as numbers establish a species' pesthood" (Graham, 1975b) and the scavenging, opportunistic habits of the gulls have brought them into conflict with farmers, public health officers, town dwellers and airport safety officers. In some cases these problems have been considered sufficiently serious to warrant control measures, which are discussed in detail in Chapter 5 of this thesis.

2.3.1 Competition with Other Species

Not all effects on other seabird species have been deleterious. Drury (1974) reported that other rapidly increasing species in North America (Double-Crested Cormorant, *Phalacrocorax auritus*; Common Eider, *Somateria molissima*; Great Black-backed Gull) usually established new colonies in existing Herring Gull colonies, and suggested that a surplus of Herring Gull colonies might therefore have facilitated population growth of these species.

However, many other species were adversely affected by increases in gull populations, due to three different types of behaviour by gulls: competition for nesting space, kleptoparasitism (or piracy) and predation upon eggs, young and adults (Thomas, 1972; Drury, 1974). A review of damage done to other species (Thomas, 1972) indicated that large gulls (Great Black-backed, Herring and Lesser Black-backed Gulls) were most often implicated in predation on other species, while kleptoparasitism was more typical of smaller gulls (Laughing Gulls, *Larus atricilla*; and Black-headed Gulls, *Larus ridibundus*), although neither behaviour was confined to either group.

Beaman (1978) noted that Great Black-backed Gulls in particular have been considered to be important predators of other seabirds, but that there was no simple relationship between the number of gulls and the threat, if any, posed to nearby colonies of other seabirds. In fact, solitary breeding pairs of Great Black-backed Gulls were found to have a significantly higher proportion of seabird prey in their diet than colonial birds.

Natural predation may actually be less frequent than is usually observed, since disturbance of a breeding colony by human researchers may increase the risk of predation by causing eggs and chicks to be left unguarded (e.g. Kury and Gochfeld, 1975).

The number of gulls present is directly relevant to the displacement of other species from breeding grounds through competition for breeding space. The increase and spread of Herring Gulls along the eastern coast of North America has been associated with the progressive displacement of breeding populations of Laughing Gulls and Common Terns (*Sterna hirundo*) (Gross, 1955; Drury, 1973; Drury, 1974; Burger and Shisler, 1978). Gross (1955) presented a pattern of succession of seabirds breeding on Maine islands: terns and Laughing Gulls followed by Herring Gulls and finally the Great Black-backed Gulls taking over. The success of Herring Gulls in competitive interactions with Laughing Gulls was attributed by Burger and Shisler (1978) to two factors: the Herring Gulls were considerably larger, and they arrived and nested earlier than the Laughing Gulls.

Displacement of other breeding species was also recorded by Duncan (1978) at the Isle of May, Scotland, where expansion of nesting area by Herring and Lesser Black-backed Gulls apparently resulted in the eventual disappearance of the four species of tern which had previously bred there. Serious and progressive damage to vegetation and soil cover had also occurred. Consequently, a gull control programme was instigated with the aim of restoring the lost species diversity and ecological balance (Duncan,1978). Control programmes have also been carried out in North America for similar reasons, leading Gross (1955) to remark: "It seems paradoxical that a bird we did so much to protect in 1900 has now to be controlled fifty years later". An extensive review of methods of control was made by Thomas (1969, 1972); control methods are discussed in Chapter 5.

2.3.2 Agricultural Pests

Although gulls are probably attracted to farm land mainly by the supply of invertebrates to be found there, they may also feed on turnips, sown grain and pig food (Lloyd, 1969), young lambs, poultry and young game birds (Brough, 1969) and even blueberries (Gross, 1955). Such damage is apparently minor, although Gross (1955) noted that there were numerous complaints from blueberry growers.

Perhaps more potentially important are the items brought to the land by the gulls.

> *The transportation by gulls of items such as tin cans from rubbish dumps on to pasture land may result in serious damage to the feet or tongues of cattle. Although unproven, there is a very real risk of the spread of infection to livestock by gulls carrying infective material such as bones from refuse tips on to pasture land or by other means. Gulls have been implicated in the infection of a herd of cattle with avian tuberculosis, and tubercle bacilli have been found in several species which are common in Britain. Abroad they have also been associated with the spread of bovine cysticercosis* (Brough, 1969).

More recently, this last disease has also been associated with gulls in Britain. Bovine cysticercosis is the infection of cattle by the human beef tapeworm, *Taenia saginata,* and Crewe and Owen (1978) have suggested that gulls could have played a part in the spread of this infection which has occurred in Britain since the second World War, by transferring eggs of the tapeworm from sewage to paddocks where they could be ingested by cattle. Considerable economic losses to meat producers have ensued, due to the required destruction or downgrading of infested beef carcasses.

Another facet of this problem is that gulls are intermediate hosts in the life cycles of certain cestodes and trematodes which infest fish (Harris, 1964; Brough, 1969). Gulls can also contribute to eutrophication of water bodies (Moss, 1981).

2.3.3 Public Health Risks

As its name suggests, the human beef tapeworm is also a parasite of humans who may become host to the adult stage after eating infected beef. Symptoms of beef tapeworm infection in humans are not usually serious, but because of its possible public health importance and undoubted economic importance as outlined in the previous section, Crewe and Owen (1978) felt that it should be brought under control.

Pollution of water supplies has been attributed to gulls, due to their habits of both feeding at sewage outfalls and rubbish tips, and roosting on reservoirs. Brough (1969) noted concern over the pollution of freshwater reservoirs with *Salmonella* types which have been found in human infections, and Duncan (1981) recorded that numbers of Herring and Lesser Black-backed Gulls nesting on Abbeystead and Mallowdale estates were controlled by the local Water Authority for reasons of public health. The fact that rooftop nesting gulls may carry *Salmonella* which are voided in the faeces was also cited as a potential health hazard in towns (Coulson and Monaghan, 1978).

Another disease potentially transmittable by gulls is influenza, since gull serum and eggs have been found to contain antibodies to human influenza A and B viruses during periods of human outbreaks of these viruses (Romvary *et al.*, 1980a,b).

2.3.4 Urban Nesting

> *Gulls may create unpleasantness by fouling pavements, buildings and property, and the noise created in the early hours of the morning by birds nesting on buildings disturbs householders* (Brough, 1969)

Added to these problems was the expense of unblocking gutters of surplus nesting material (Murton, 1971).

Since these authors made their comments, the number of urban nesting gulls has increased markedly, and is likely to continue to grow rapidly (see Section 2.1.2a). The problem is further magnified because colonies become more stable as they grow in size, and are thus more difficult to dislodge, while the problems they create intensify.

While they also nest on rooftops of commercial and industrial buildings, gulls have caused most trouble in residential areas. The kind of offences described above, as well as aggressive "dive-bombing" in defence of young, have frequently caused residents to complain to district authorities. Various control measures have been attempted, but with little success (Monaghan and Coulson, 1977; Monaghan, 1979; Coulson and Monaghan, 1978).

2.3.5 Aircraft Bird-Strikes

Gulls have been involved in up to half of all aircraft bird-strikes in Europe, Britain and North America. The great majority of gulls involved are smaller gulls: Black-headed Gulls and Common Gulls (*Larus canus*) in

Britain (Grant, 1974; Rochard and Horton, 1980); Franklin's (*Larus pipixcan*) and Bonaparte's (*Larus philadelphia*) Gulls in North America (Solman, 1978). Large gulls were involved much less frequently, which probably reflected the composition of flocks of gulls using airfields. Small gulls fed extensively on airfields or the surrounding grassland, while large gulls appeared to be attracted to the airfields mainly as a secure loafing area (Grant, 1974; Rochard and Horton, 1980).

Increases in gull populations could be expected to increase the number of bird-strike incidents involving gulls. Solman (1981) has described how technological changes in the aircraft industry have also raised the likelihood of bird-strikes. The nature of jet engines means that birds are not only more likely to be sucked into the engine by the air flow, but the engines are also more sensitive to damage by the birds. The bird-strike rate has risen further with the advent of the newer wide-bodied aircraft. These planes are both quieter and faster, which gives birds a shorter warning period of the approach of the plane, and also have larger air intakes which means that the birds have to move further to escape ingestion.

The cost of aircraft striking gulls is enormous, both in terms of money and of human lives or injuries. Grant (1974) and Solman (1978) suggested that careful observation of the behaviour patterns of gulls in the vicinity of individual airfields would enable action to be taken to minimize the number of strikes involving these birds. For example, "gull reports" could become a part of routine flight procedures.

Brough (1969) attributed another kind of airfield hazard to gulls: they occasionally dropped objects such as tin cans onto runways where they could damage aircraft tyres or be ingested into jet engines.

2.4 Future Trends

Unless circumstances change dramatically, indications are that populations of the large gulls discussed earlier in this chapter will remain high and continue to increase in most areas of the Northern Hemisphere. While there is some evidence that the breeding population of Herring Gulls in the Maine area of eastern North America may have begun to stabilize (Drury and Kadlec, 1974), overall numbers of this species will continue to rise because both the size and number of colonies further south are still increasing (e.g. Burger and Shisler, 1978). Within Britain, the steady annual Herring Gull population growth rate of 13% is being further supplemented by the even more rapid increase occurring within urban colonies. As discussed in Section 2.1.2, urban colonies are likely to continue to grow very rapidly, and the impact of town-nesting birds will be felt more strongly as the numbers involved increase. This scenario led Coulson and Monaghan (1978) to comment that "This bird is about to enter a period of increase hitherto contemplated only by Hitchcock addicts".

Continued gull population increases and the accompanying exacerbation of all of the effects noted in Section 2.3 will probably lead to an intensification of efforts to control numbers. Coulson and Monaghan (1978) reported that none of the methods tried for controlling gull numbers in towns had been satisfactory, but numbers have been greatly reduced in a natural colony (Duncan,1978) and Duncan (1981) predicted that the Abbeystead and Mallowdale colony was likely to be much reduced in future because of the control measures being implemented in that colony. With the likelihood of artificial control of gull populations becoming more widespread, there is a need for more thorough understanding of the biology of the gull, for definition of what "acceptable" numbers might be, and for methods of quantifying the benefits of control (Duncan, 1981).

Natural factors may also operate to control gull population size. Mudge (1981) noted an overall decline in the number of breeding pairs of Herring, Lesser Black-backed and Great Black-backed Gulls at the inner Bristol Channel colonies between 1975 and 1980. Preliminary investigation showed that the reduction may have been the result of excessive adult mortality during the breeding season due to botulism, which had earlier been recorded by Lloyd *et al.* (1976) as the cause of widespread gull mortality during the hot 1975 summer and attributed to the gulls' habits of feeding at tips and using warm shallow pools which favour the growth of the causative organism, *Clostridium botulinum*.

Increasing density within breeding colonies would lead to intense competition for territories, which may then limit the size of particular colonies. Further population growth would only occur through colonization of new areas, as is happening in North America. Once all suitable areas have been fully utilized, the overall population size would be expected to be stable. However, gulls have already shown their adaptability to different nesting habitats (Section 2.1.2) and so it becomes very difficult to define what constitutes "suitable" habitat. Apart from limitation of the number of pairs which can breed, high nesting density may lower the reproductive success of individual pairs due to increased aggression by neighbours when territories are small (Ewald *et al.*, 1980).

High nest density has also been suggested by Graves and Whiten (1980) and Holley (1981) as a factor contributing to a high incidence of adoption of strange young by adult Herring Gulls. While adoption appeared to be beneficial to the foreign chick (Graves and Whiten, 1980), there were no apparent benefits to the adopting parents, leading Holley (1981) to suggest that Herring Gulls had not yet fully adapted to the high nest densities which have been brought about by dramatic population increase.

Holley (1981) also noted cases of adoption of Lesser Black-backed Gull chicks by Herring Gull adults. Such natural interspecific adoption and deliberate experimental cross-fostering may cause wrong imprinting of the chick, which results in the formation of mixed pairs and hybrid offspring when the cross-fostered bird reaches the reproductive stage. The low proportion of hybrids found in relation to the scale of cross-fostering experiments suggested to Harris *et al.* (1978) that hybrids were at considerable selective disadvantage, although Brown (1967b) thought this unlikely due to the great overlap of niches of Herring and Lesser Black-backed Gulls because of the increased availability of human refuse. Hybrids between Herring Gulls and Glaucous Gulls (*Larus hyperboreus*) in Iceland had proved so vigorous that much of the Icelandic population of these gulls was of hybrid origin (Harris *et al.*, 1978). However, Herring Gulls apparently hybridize much less readily with Lesser Black-backed Gulls, and Kilpi *et al.* (1980) considered that the dense Herring Gull population in Finland had, together with human disturbance during the nesting season, been responsible for the decline in the Lesser Black-backed Gull population of that country.

The effects of high gull populations on other species, already noted in Section 2.3, continue to be felt particularly in areas where the gulls are still extending their range. Parnell and Soots (1975) wrote that

> *Southward breeding range extension of Herring and Great Black-backed Gulls may have ominous ecological significance. Both are predators on the young of other colonial nesting birds and represent new and perhaps important factors in the breeding ecology of such regular North Carolina nesters as the Royal Tern (*Thalasseus maximus*), Common Tern (*Sterna hirundo*) and Laughing Gull.*

Similarly, Burger and Shisler (1978) expected that Herring Gulls would continue to increase at the expense of Laughing Gulls. There is special cause for concern in the case of rare species, such as Audouin's Gull of the Mediterranean area, which may be limited by nest occupation by the stronger and more numerous Herring Gull (Brichetti and Cambi, 1979).

The protection which allowed gulls to increase this century (discussed in Section 2.2.1) is still not enjoyed by all species in all areas. Another factor suggested by Brichetti and Cambi (1979) as contributing to the apparent decline of Audouin's Gulls was the removal of eggs and nests by fishermen and collectors. Chronic destruction or removal of eggs has also caused concern for the future of a subspecies of Western Gull endemic in the Gulf of California area of Mexico (Hand, 1980).

Even when effective protection from removal of eggs or killing of birds is afforded, several authors have recently shown that human disturbance can nevertheless be seriously disruptive and damaging to the reproductive success of breeding seabirds. Paradoxically, this disturbance may result not from malice but from an increased appreciation of natural phenomena. Visits to breeding colonies by recreationists, educational groups, local fishermen and scientists all cause nesting birds to leave their nests, exposing their eggs or chicks to unfavourable environmental conditions and to conspecific and interspecific predation (Hunt, 1972; Kury and Gochfeld, 1975; Anderson and Keith, 1980; Hand, 1980). The magnitude of this damage could be minimized if human access was carefully regulated. Management recommendations made by Kury and Gochfeld (1975) and Anderson and Keith (1980) involve control over access to colonies, isolation of critical areas in sanctuaries and the appointment of wardens. Burger (1981b) showed that there may also be a need to limit human activities in bird refuge areas during the non-breeding season, especially for the benefit of migrating shorebirds.

Passage of aircraft may have a similar effect to pedestrian human disturbance. Subsonic fixed wing aircraft and helicopters do not appear to affect nesting gulls (Dunnet, 1977a; Burger, 1981c) but supersonic transports caused gulls to fly from their nests and many eggs were broken in the ensuing melee (Burger, 1981c).

Since the amount of food provided by man has been considered important in allowing gull numbers to reach their present high levels (Section 2.2.2), human activities with the potential to affect gull populations in the future include those which alter the amount of food available to gulls. Increasing standards of public health and pollution control are likely to result in changes in the methods of treatment of sewage and garbage. Hickling (1969) noted that open tipping of garbage was likely to be increasingly replaced by alternatives such as incineration and pulverization of wastes. Where this change had already occurred, gulls had become much less of a pest because they no longer flew along concentrated flight lines to a few large feeding sites. However, incineration of garbage is unlikely to become very widespread in the future, because of air pollution problems which have already forced the closure of some incinerators in the United States of America (Nisbet, 1978). A common change in disposal technique is from open dumps to "sanitary landfills" which Nisbet (1978) felt probably did not decrease the amount of garbage available to gulls but might reduce access to it. Access to refuse by gulls may also change in some areas due to competition with Great Skuas (*Stercorarius skua*). Furness *et al.* (1981) noted feeding by this species on a refuse tip and fish offal at Shetland; a change in behaviour to utilize this food source could conceivably lead to an increase of the Great Skua in Britain.

Changes in the treatment of sewage are likely to have adverse effects on gulls. Fuller and Glue (1980) noted that recent technical advances meant that sewage farms were being replaced by smaller works which supported fewer wetland species, but were still utilized by gulls in winter. Fitzgerald and Coulson (1973) studied gulls feeding on a river which was heavily polluted by untreated sewage. They predicted that a sewage scheme which was proposed to solve some of the pollution problems in the river would result in the disappearance of Lesser and Great Black-backed Gulls from the area and reduce the number of Herring Gulls by 60%, although the analysis did not take into account any new food sources which could appear once the pollution ceased.

Other forms of water pollution are likely to be harmful to gulls. Kocwa and Szewczyk (1969) reported that oil and grease contamination of water caused high mortality among gulls in Poland, and oceanic pollution was included by Brichotti and Cambi (1979) in their list of causes of the apparent decline in numbers of Audouin's Gull. A decline in the Great Lakes population of Herring Gulls was associated with the effects of toxic chemicals (Nisbet, 1978). Bourne and Bogan (1980) found that gulls as a group appear to be rather resistant to organochlorine contamination, but stressed (as did Drury, 1974) the need to continue to watch the situation regarding this and other forms of pollution.

3
Gulls in Australia

3. GULLS IN AUSTRALIA

The Australian continent has an enormous length of coastline and spans about 35° of latitude, but it has by far the lowest number of gull species of any continent. Until recent years Australia supported only two species of gull: the small Silver Gull (*Larus novaehollandiae*) and the large Pacific Gull (*Larus pacificus*). By comparison, there are six species of gull around the coast of southern Africa and nine species around South America (Tuck, 1980).

A third species, the Kelp Gull (*Larus dominicanus*), has become established in Australia within the last thirty years. It is a widespread species, distributed around all the southern continents including Antarctica, and on the sub-antarctic islands and New Zealand (Tuck, 1980). In Australia it has established itself in areas occupied by the Pacific Gull. The similarity in size and appearance between the Kelp and Pacific Gulls suggests that they may be in close competition for resources. Soon after the Kelp Gull had begun to spread it was feared that the Pacific Gull could decline as a result (Ford, 1964); this concern has been echoed by a number of ornithologists since (e.g. Simpson, 1972).

This chapter reviews current biological knowledge of the three Australian gulls. The Silver Gull is examined mainly in terms of its feeding ecology and population dynamics to assess the impact of human activity on its numerical status. Although the Silver Gull has been the subject of several studies in other parts of its range, particularly in New Zealand (e.g. Mills, 1979), this discussion is limited to information from Australian populations.

The two large species are discussed in more detail so that the various aspects of their ecology can be compared directly. The sections on these two species represent a comprehensive review of the available literature. Many studies investigating the ecology of the Kelp Gull have been conducted in widely separated parts of its range, and a fairly complete picture of its ecological niche can be built up. Unfortunately, there has been far less research on the Pacific Gull and much of the available information is anecdotal or fragmentary, so any analysis of past and present trends is necessarily limited.

3.1 The Silver Gull

3.1.1 Description and Distribution

The familiar Silver Gull, *Larus novaehollandiae* Stephens, is described by Simpson (1972) as follows:

> *The adults are spotlessly white, with pearly grey upper wings and bright red bills, legs and feet. A red orbital ring surrounds a silver-white iris. The outer portion of the primary wing feathers is partly black with small white spots. Immature and sub-adult birds have duller brownish or red and black bills, and browner legs.*

Body length, from beak to tail, is 36-38 cm and the wing-span is 92 cm (Tuck, 1980). Serventy *et al.* (1971) give the adult body weight as 10-12 oz (280-340 g).

Taxonomically, the Silver Gull is included in a widespread group referred to as "masked gulls" (Moynihan, 1959; Schnell, 1970a,b) although it lacks the dark facial mask typical of this group. A number of subspecies have been described based on the number of spots (mirrors) on the black outer primaries and on other morphological characteristics such as bill length. Two subspecies, Hartlaub's Gull (*L. n. hartlaubi*) of South Africa and the Red-billed Gull (*L. n. scopulinus*) of New Zealand are geographically separated races, but the Australian subspecies are less clearcut because they show a latitudinal cline in characteristics. Three subspecies are often recognized: *L. n. forsteri* of New Caledonia, northern Australia and Queensland; *L. n. novaehollandiae* of New South Wales, Victoria, South Australia and Western Australia; *L. n. gunni* of Tasmania (Carrick *et al.*, 1957; Simpson, 1972). However, the Royal Australian Ornithologists Union checklist accepts only two Australian subspecies and merges the Tasmanian race with the nominate race of southern Australia (Condon, 1975).

The distribution of the Silver Gull is continuous around the coast of Australia. The species is also widely distributed inland, particularly in the south of the continent as shown in Figure 3.1. Its breeding sites, especially the inland colonies, are also concentrated in the southern half of the continent. The distribution of the Silver Gull is shown in Figure 3.2.

FIGURE 3.1

The Distribution of the Silver Gull (*Larus novaehollandiae*) in Australia, from the Royal Australasian Ornithologists Union Field Atlas Interim Printout (to 31 January 1981)

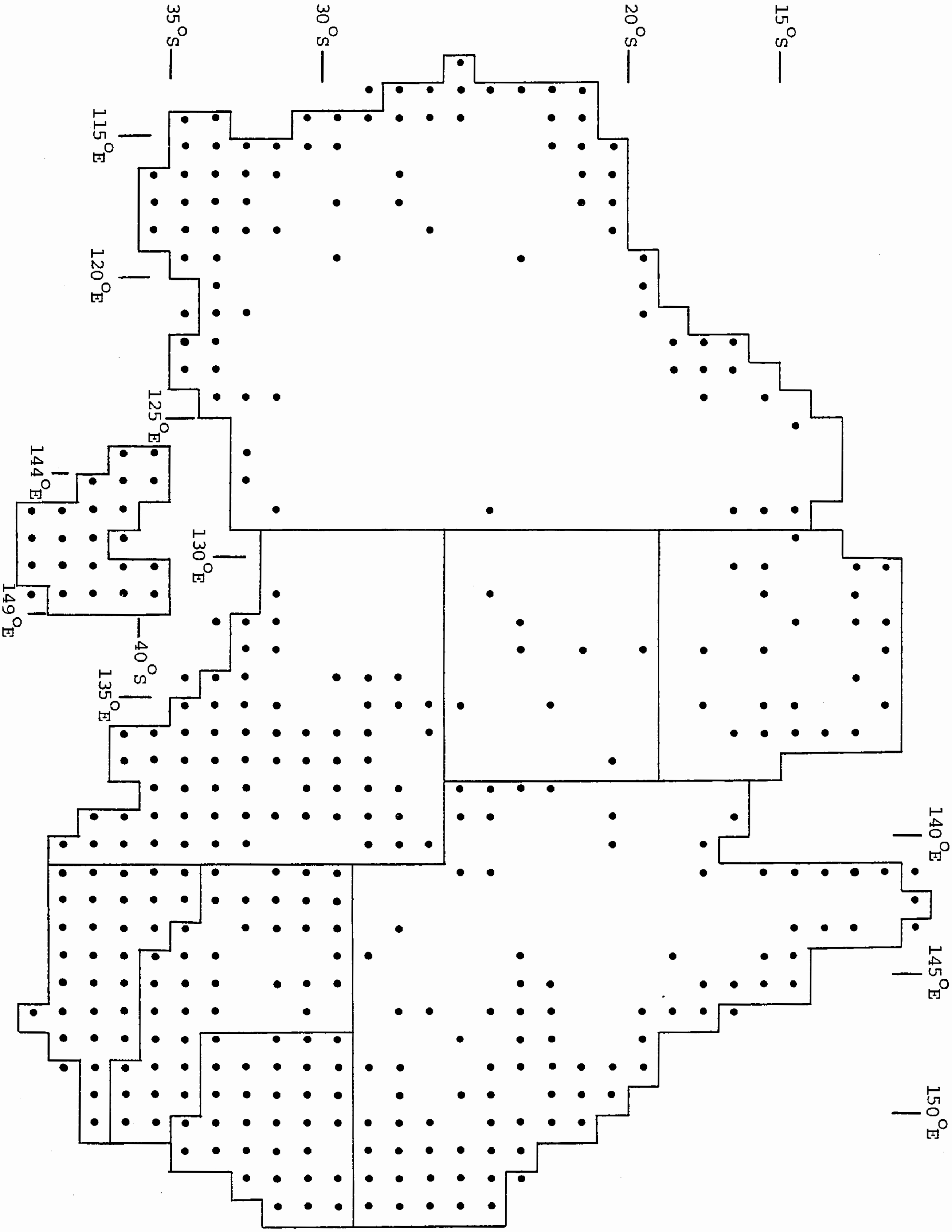
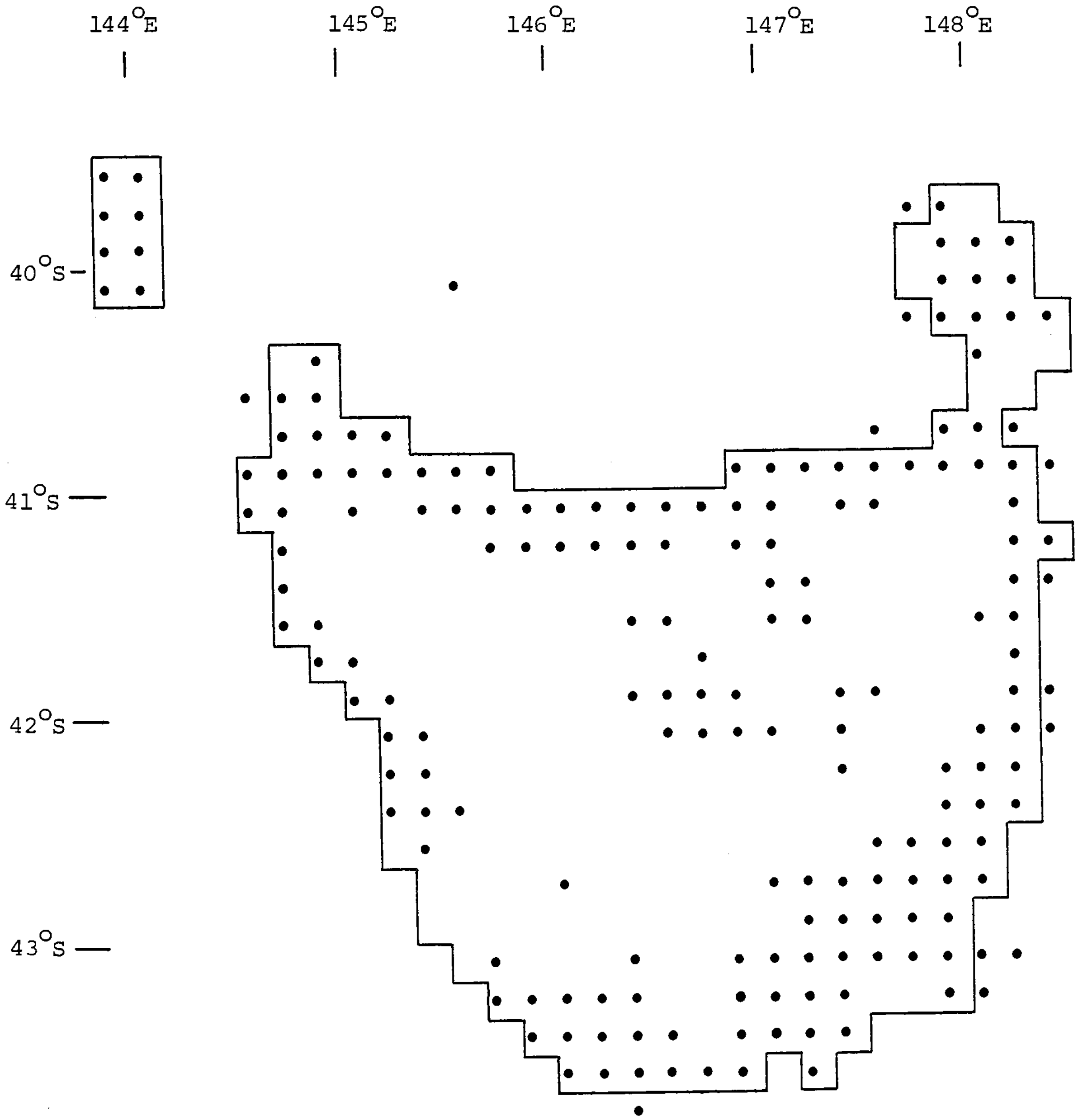


FIGURE 3.2

The Distribution of the Silver Gull (*Larus novaehollandiae*) in Tasmania, from the Royal Australasian Ornithologists Union Field Atlas Interim Printout (to 31 January 1981)



3.1.2 Feeding Ecology

The Silver Gull has been described as "an omnivorous and versatile feeder" which utilizes a wide variety of feeding resources in proximity to expanses of salt or fresh water (Murray and Carrick, 1964).

(a) Natural feeding sites

The major natural feeding sites are listed by Carrick and Murray (1964) as coastal mudflats, shallow (especially salt) water and tidal beaches, particularly wet sand, indicating that they are predominantly coastal birds. However, they also feed offshore (i.e. within sight of land) and Abbott (1979) has recorded them up to 20 nautical miles (36 km) from land in Western Australia when calm seas permit successful surface feeding. The types of natural food taken include: small fish; small crustaceans and molluscs; other invertebrates such as marine worms, kelp fly larvae and swarming ants; plant material including saltbush (*Rhagodia*) and heath (*Leucopogon*). Specific details of diet for Silver Gulls in Victoria are given by Wheeler and Watson (1963). Silver Gulls may be quite successful in stealing fish from other species, such as Crested Terns (*Sterna bergii*), as reported by Hulsman (1976). Dann (1979) recorded kleptoparasitism on four species of waders, and found that foraging success of Bar-tailed Godwits (*Limosa lapponica*) was significantly reduced when subject to kleptoparasitism by Silver Gulls. They have also been recorded preying on the eggs and chicks of other seabirds such as cormorants, but Serventy *et al.* (1977) consider that the gulls are making use of unusual opportunities caused by human disturbance of the nesting colony.

(b) Man-made feeding sites

Silver Gulls have extended their foraging activities to a number of new food sources created by human activity:

(i) Agricultural land has provided an expanding food source. Gulls feed on soil organisms by "following the plough", especially in Victoria and South Australia (Wheeler and Watson, 1963), and also congregate on pasture (Carrick and Murray, 1964). In southern Tasmania this is most noticeable in wet weather when they presumably feed on organisms forced to the surface, as has been noted in water-logged grassy areas at an airport by Van Tets (1969a). Serventy *et al.* (1971) state that they also eat strawberries.

(ii) Shipping and fishing are exploited by Silver Gulls which follow the wake of vessels and dive for scraps thrown overboard, particularly offal from fish cleaning (Simpson, 1972; Wheeler and Watson, 1963). Carrick and Murray (1964) point out that the propellors of vessels churn up the mud in shipping channels and bring small invertebrates to the surface. In Tasmania, Silver Gulls have always been common at the docks in Hobart (Sharland, 1956; Harris, 1980).

(iii) Sewage outfalls, including domestic sewage and discharges from abattoirs and food-processing plants attract large flocks of feeding gulls (Hindwood, 1955; Serventy *et al.*, 1971). Silver Gulls also gather at settling ponds in sewage treatment plants in the Hobart area.

(iv) Solid wastes can attract large numbers of Silver Gulls, and there are numerous references to them feeding at rubbish tips (e.g. Wheeler and Watson, 1963; Murray and Carrick, 1964; Van Tets, 1969a; Loyn, 1978; Gibson, 1979). In Tasmania, a study of rubbish tips in the Hobart area concluded that they were important food sources for the local Silver Gull population (Mitchell, 1980).

(v) Urban areas have been increasingly utilized by Silver Gulls. Sharland (1956) noted that Silver Gulls had become more common and fearless in the parks of Hobart. They now scavenge at picnic areas, sports grounds, shopping centres, schools and anywhere else where food scraps may be discarded; they even forage at night in artificially lit areas (Gibson, 1979).

3.1.3 Status

The Silver Gull has always been a common species. In the mid-nineteenth century John Gould (1865) commented that it " ... is abundantly dispersed over the sea-shores of Tasmania and the southern coasts of Australia generally." Early this century Littler (1910) stated

> *Of the various species of sea-birds, frequenting the coasts of Tasmania, the Silver Gull is the most familiar. It frequents the sea-shore and the mouths of rivers rather than the open ocean. It congregates often in immense flocks, especially at low tide, along the beach or on reefs and schoals.*

Associated with its opportunistic feeding habits, the Silver Gull has demonstrated its ability to establish new breeding colonies, often in areas made suitable by human activity (Wheeler and Watson, 1963). Its breeding potential is quite high; the upper limit is probably displayed by birds of a colony studied near Perth which have a nine month breeding season and are capable of fledging two broods per year (Wooller and Dunlop, 1979). Studies of seasonal movements of Silver Gulls by Carrick *et al.* (1957), Murray and Carrick (1964) and Carrick and Murray (1964) showed the importance of bays with large human populations nearby as winter feeding resources, and concluded that the Silver Gull population was not increasing at anywhere near its potential rate because of intraspecific competition for food. However, Sharland (1956) drew attention to a rise in Tasmania's Silver Gull population which he attributed to the increased amount of food available from fishing boats and canneries around the coast; he considers (pers. comm., 1981) that this growth is still continuing. A similar trend has been shown along the coasts of South Australia (Boehm, 1961) and of Victoria where Wheeler (1976) concluded that " ... there is little doubt that the number of Silver Gulls is increasing".

There have only been two well-documented accounts of population growth in Silver Gulls. Gibson (1979) showed that the breeding colony on the Five Islands Group (in New South Wales) has increased from less than 1 000 pairs prior to 1940 to 51 500 pairs in 1978. This spectacular increase was closely correlated with the growth of the human population in Port Kembla and Wollongong on the adjacent coastline. In Victoria, the colony on the Mud Islands in Port Phillip Bay has grown since breeding was first recorded in 1952 to 3 000 - 4 000 pairs in 1980, probably as a result of residential development on the nearby Mornington Peninsula (Kerry and Hall, in press).

The increased population density of Silver Gulls appears to have had little documented impact on the environment. One impact which has been reported is the modification of breeding areas. Gillham (1960) showed that the indigenous heath vegetation of Victorian sea-bird islands was progressively destroyed by physical disturbance and toxic guano produced by breeding birds; gulls were not the only species implicated, but men and gulls added to the damage by introducing weeds. Gibson (1979) also noticed vegetation changes on the Five Islands and a concomitant decline in the numbers of burrowing seabirds. The only other impact of Silver Gull numbers is the incidence of collisions with aircraft. The Silver Gull is the species most commonly involved in Australian bird-strikes, and strikes have been reported at 12 airports (Van Tets *et al.*, 1977). They were a particular problem at Sydney Airport where a number of management measures were adopted which successfully reduced gull numbers and the frequency of bird-strikes (Van Tets, 1969a,b). Silver Gulls also became a hazard at Devonport Airport so the population was reduced by modifications to nearby roosting and nesting islands (Van Tets, 1977a).

3.2 Pacific Gull

3.2.1 Classification

Since it was first described in 1801, the Pacific Gull, *Larus pacificus* Latham, has been the subject of some taxonomic debate. It was originally placed within *Larus*, a cosmopolitan genus which includes most species of gull. This arrangement was retained in a classic work by Dwight (1925), but Peters (1934) removed the Pacific Gull and the South American Dolphin Gull (now *Larus scoresbii*) from *Larus* and created the genus *Gabianus* for them apparently on the basis of their stout bills, a characteristic shared by the two species.

In a major revision of the gull family (Laridae), Moynihan (1959) pointed out that in all other morphological features the Pacific Gull is closer to his group of large white-headed gulls; this group includes the Herring Gull, the Lesser Black-backed Gull and the Great Black-backed Gull of the Northern Hemisphere, and the Kelp Gull of the Southern Hemisphere. Moynihan reinstated the Pacific Gull in *Larus*. A phenetic study by Schnell (1970a,b) supported Moynihan's classification: on the basis of a large number of skeletal and external characteristics, the Pacific Gull is most similar to a group of white-headed gulls composed of the Herring, Lesser Black-backed and Kelp Gulls as well as the Western Gull (*Larus occidentalis*), the Glaucous-winged Gull (*Larus glaucescens*) and Thayer's Gull (*Larus thayeri*). However, Moynihan's classification was based primarily on ethological characteristics which were not available for the Pacific Gull; observations of behaviour reported in the literature and made in the course of this study (see Section 3.2.4) suggest that the Pacific Gull does not share key elements of the behavioural repertoire of the white-headed gull group. Further study is needed to clarify the taxonomic position of the Pacific Gull.

Two subspecies of the Pacific Gull have been suggested (Van Tets, 1976): the subspecies occurring in eastern Australia, *L. p. pacificus*, has a bi-coloured bill, and the western subspecies, *L. p. georgii*, which extends from Kangaroo Island in South Australia to Western Australia, is distinguished by a tri-coloured bill (see Section 3.2.2).

3.2.2 Description

The Pacific Gull is one of the largest species of gull, only a little smaller than the Great Black-backed Gull. Tuck (1980) gives dimensions for the Pacific Gull as: length 64 cm, wing-span 137 cm. Its most distinctive feature is the heavy bill which is the most robust of any gull (Pizzey, 1980). The shape of the bill is shown in Figure 3.3.

As part of this study, gonys and culmen measurements (see Figure 3.3) were taken from specimens held in Tasmania museums (Queen Victoria Museum in Launceston and Tasmanian Museum in Hobart) and others provided by the Tasmanian National Parks and Wildlife Service. Despite the small size of the available sample, there was a clear sexual dimorphism in bill size as shown in Table 3.1: males have a bill which is longer, and deeper at the gonydeal angle, as has been found in other *Larus* gulls (e.g. Harris and Hope Jones, 1969). The dimorphism was apparent in both first year and adult birds, and there was no overlap between the sexes in the adult birds. The sexes of birds in pairs could be readily determined by eye in the field.

TABLE 3.1

Means and Standard Deviations for Body Weight and Bill Measurements of Pacific Gulls in Tasmania

Age	Sex	Sample Size	Body Weight (g)	Culmen (mm)		Gonys (mm)	
1st year	o	5	1248 ± 353	59.3 ± 2.4	**	28.3 ± 0.4	*
1st year	♀	8	1091 ± 187	55.4 ± 2.2		26.6 ± 1.5	
adult	o	4	1482 ± 302	62.7 ± 1.9	***	30.8 ± 0.8	**
adult	♀	5	1253 ± 127	55.9 ± 1.4		27.5 ± 1.9	

Confidence limits using t-test (two-tailed test):
* - 5%; ** - 2%; *** - 1%.

Body weights were extracted from the museum records and were measured for some fresh specimens. They are given in Table 3.1. There was a possible sexual dimorphism in body weight, but the characteristic was highly variable, with a range from 840 g for a first year male to 1800 g for an adult male.

FIGURE 3.3

A Comparison of the Bills of the Pacific Gull and the Kelp Gull showing their Shape, Distribution of Colour and Measurements Taken

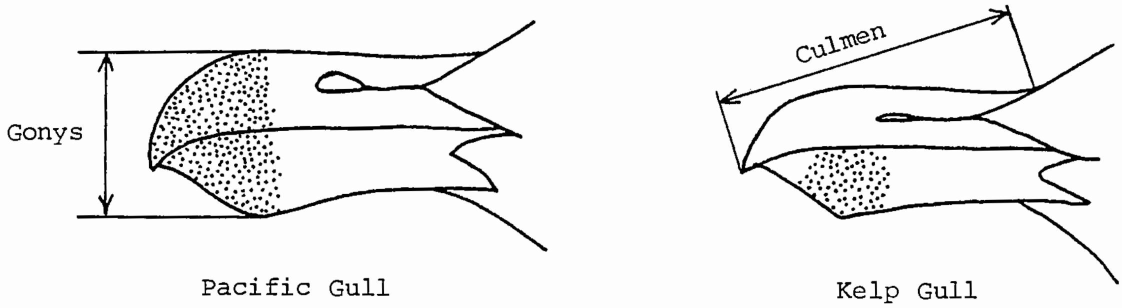
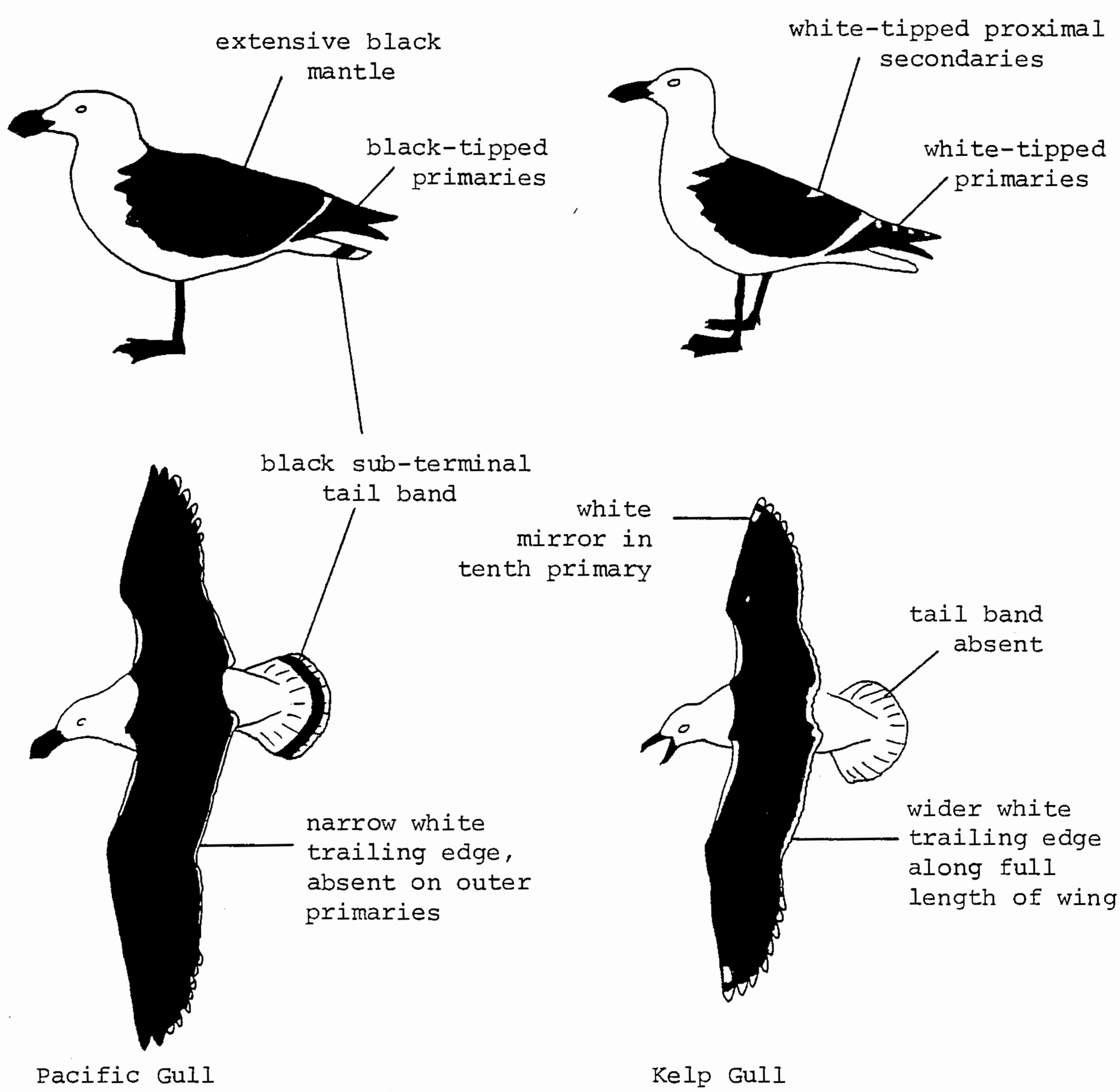


FIGURE 3.4

Adult Plumage of the Pacific Gull and the Kelp Gull in Flight and at Rest. Drawn from Pizzey (1980), Tuck (1980) and Field Photographs



The mean weight of all specimens, including a number of unknown sex and some in poor condition, was 1226 g (N=23) which was above the range of 2-2½ lb (907-1134 g) give by Serventy *et al.* (1971).

The appearance of the Pacific Gull changes with age. Birds in their first year are quite unlike the adults in their colouring, and many people refer to them as "nellies" or "mollyhawks" (Serventy *et al.*, 1971), believing them to be different species (see Plate 3.1). They have a fairly uniform dark brown plumage, darkest on the head and neck (Simpson, 1972), but often with some lighter mottling on the breast. The bill tip (see Figure 3.3) is slate grey with variable shades of brown on the base of the bill, and the legs, feet, iris and eye ring are dark brown.

In their first few years of life, Pacific Gulls go through a series of moults which result in a succession of mottled phases as they mature. Robertson (1981a) states that full adult plumage is attained in the fifth year. The plumage changes are summarized by Pizzey (1980): the head, neck and breast become lighter as they change to pure white in the adult; the back and wings darken to form the black mantle with a narrow white border on the leading and trailing edges; the tail becomes white with a broad black sub-terminal band. This tail band readily distinguishes it from the Kelp Gull in flight, as shown in Figure 3.4.

The progressive changes in colouration of the soft parts are summarized by Robertson (1981a): a bright yellow colour develops on the legs and feet and the base of the bill; the iris becomes white with a fine mottling of brown and the eye ring becomes yellow; the bill tip turns bright red. The western subspecies also has a narrow black line on the cutting edges of the bill (Van Tets, 1976). Plate 3.2 shows an adult of the eastern subspecies.

3.2.3 Distribution

The Pacific Gull is endemic to Australia, and is largely restricted to the coast of the southern portion of the continent as shown in Figure 3.5. On the east coast the Pacific Gull extends about as far north as Newcastle ($32^{\circ}50'$ S) according to Pizzey (1980), although there have been two published sightings in southern Queensland (Vernon and Filmer, 1972). There is some evidence that the species was far more common in

PLATE 3.1

Juvenile Pacific Gull

PLATE 3.2

Adult Pacific Gull

FIGURE 3.5

The Distribution of the Pacific Gull (*Larus pacificus*) in Australia, from the Royal Australasian Ornithologists Union Field Atlas Interim Printout (to 31 January 1981)

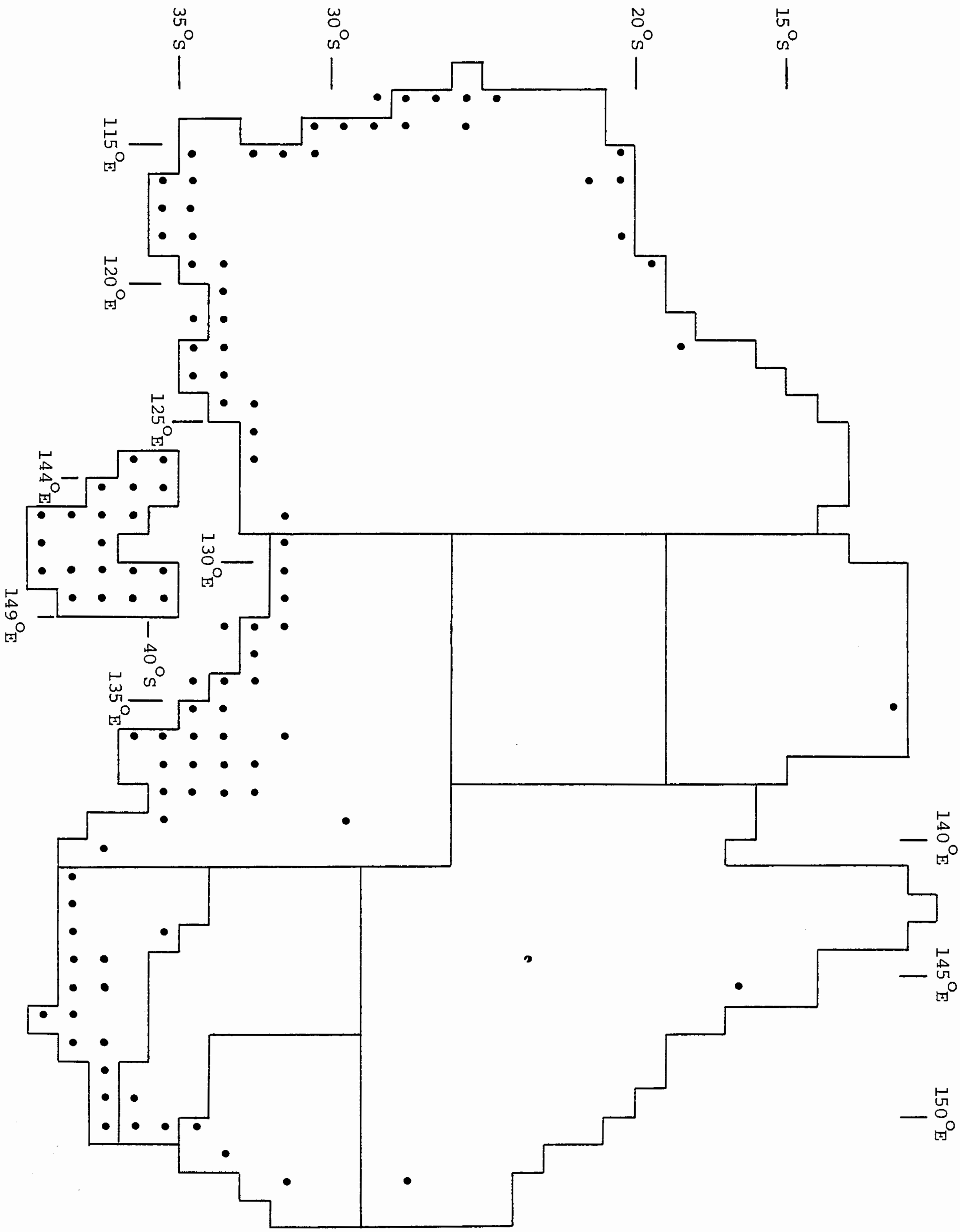
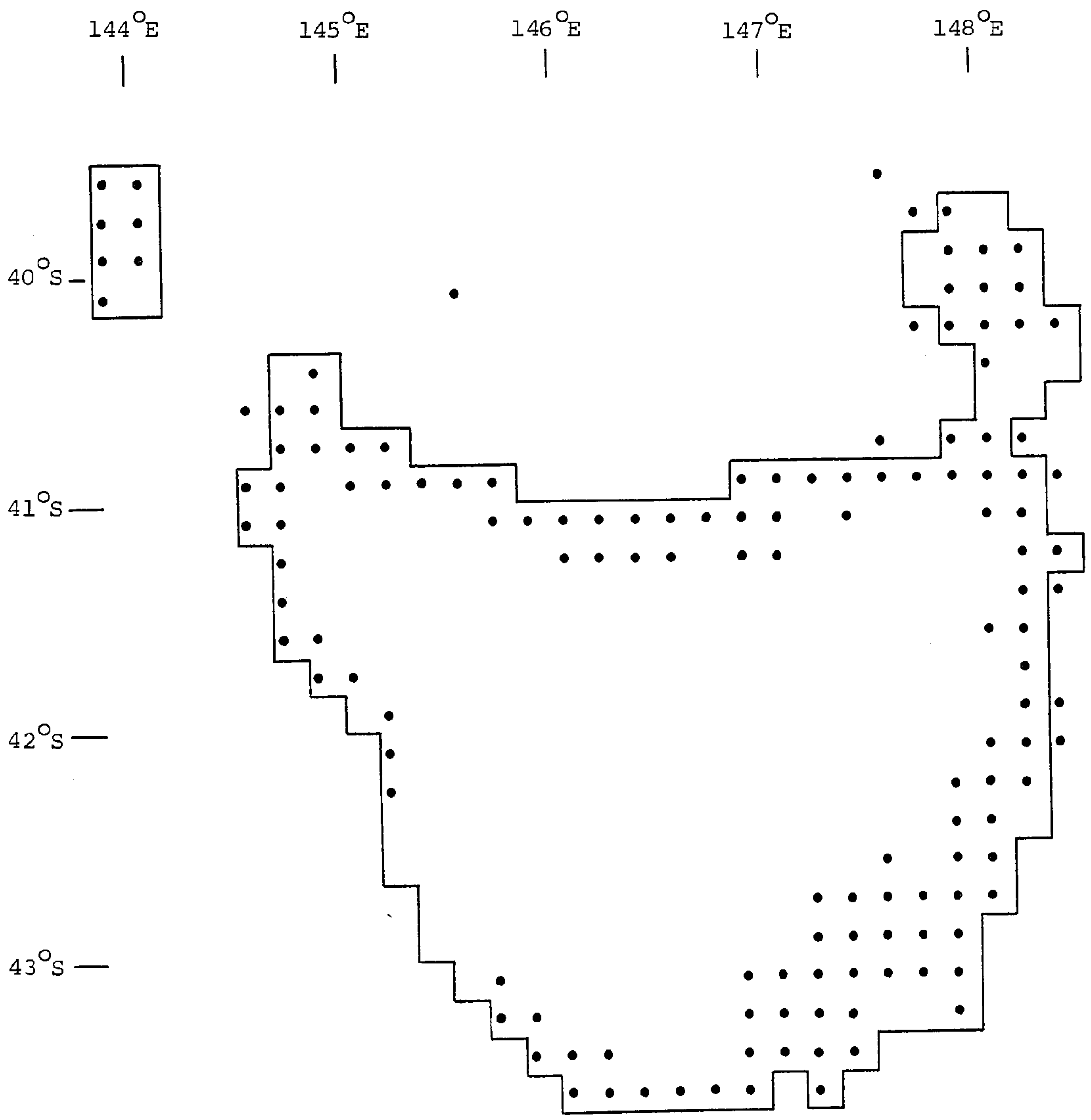


FIGURE 3.6

The Distribution of the Pacific Gull (*Larus pacificus*) in Tasmania, from the Royal Australasian Ornithologists Union Field Atlas Interim Printout (to 31 January 1981)



Queensland and New South Wales early in the twentieth century and has since suffered a reduction in range. On the west coast, by comparison, the Pacific Gull appears to have expanded its range northward from Shark Bay to Point Cloates ($22^{\circ}40'$ S) during the present century (Serventy and Whittell, 1976). Pizzey (1980) gives the northerly limit as Point Cloates, but the R.A.O.U. Field Atlas (see Figure 3.5) has a number of sightings further north in the Pilbara Region.

In Tasmania, the Pacific Gull is distributed around the coast as shown in Figure 3.6. The Bass Strait Islands are regarded as the stronghold of the species (Pizzey, 1980).

The breeding distribution of the Pacific Gull is more restricted. It extends from Shark Bay in Western Australia (Serventy and Whittell, 1976) around the coast to Wilson's Promontory in Victoria (Harris and Norman, 1981) and to islands off south-east Tasmania (White, 1980). The species breeds on islands, or occasionally on isolated peninsulas, and there are three main breeding zones: Bass Strait, the Gulf areas of South Australia and the Recherche Archipelago of Western Australia (Serventy *et al.*, 1971). Table 3.2 lists the known breeding sites in Tasmania.

3.2.4 Behaviour

Gulls, particularly the Northern Hemisphere species have been the subject of extensive behaviour studies (e.g. Tinbergen, 1959). However, of the genus *Larus*, probably the least studied is the Pacific Gull (Farr, 1978), and it is necessary to combine a number of isolated reports with our own observations to obtain a rudimentary picture of its behaviour.

(a) Individual behaviour

Adult Pacific Gulls are generally regarded as sedentary (Serventy *et al.*, 1971). Ford (1963) noted that four pairs in Western Australia which bred regularly on four small islands could be found in the vicinity of these islands throughout the year. Our observations in the Hobart area suggest that many adults take up feeding territories for the duration of the non-breeding season (see Section 4.3).

In contrast, juvenile birds often disperse widely from their natal islands. A young bird banded in Western Australia by Ford (1963) was found

TABLE 3.2

Breeding Sites of the Pacific Gull in Tasmania

Locality	Reference
Hogan-Kent Groups	
Rodondo Island	h
Hogan Island	h
North-east Island	h
Furneaux Group	
Cat Island	h
Rabbit Island	h
Samphire Island	h
Woody Island	h
Forsyth Island	h
Apple Orchard Reef	h
Paddy's Island	m
Rum Island	k
Chalky Island	g
Little Chalky Island	n
Billy Goat Reef	o
Goose Island	o
Kangaroo Island	o
Mile Island	o
Marshall Bay (rocks)	o
Big Green Island	o
Doughboy Island	o
Fisher Island	o
Craggy Island	p
North-west Coast	
East Robbins Island	h
Snob Rock	h
Penguin Island	h
North Coast	
West Islet	h
Wright's Island	h
East Inlet, Stanley (spit)	p
Crayfish Creek (small island)	m
North-east Coast	
Little Waterhouse Island	h
Baynes Island	h
Maclean Island	h
Pelican Island	h
Foster Island	h
East Coast	
The Nuggets	a
Lachlan Island	e
St. Helens Island	f
Paddy's Island	m
George's Rocks	d

Table 3.2 Contd.

Table 3.2 Continued

Locality	Reference
South-east Coast	
Green Island	h
Curlew Island	h
Southport Island (Blanche Rock)	h
Vischer Island	c
Arch Island	i
Sterile Island	j
South-west Coast	
Walker Island	h
Flat Island	h
Shanks Island	h
Kathleen Island	h
Ile du Golfe	l
Louisa Bay	b
Payne Bay, Port Davey	p

a. Brothers (1980).
b. Green and Mollison (1961).
c. Jones, 1979).
d. Napier and Singline (1979).
e. Newman (1973).
f. Newman (1974).
g. Robertson (1981b).
h. Serventy *et al.*, (1971).
i. Thomas (1976).
j. Thomas (1978).
k. Whinray (1982).
l. White (1981).
m. Napier (pers. comm. 1981).
n. Robertson (pers. comm. 1981).
o. Wakefield (pers. comm. 1981).
p. National Parks and Wildlife Service, Tasmania (unpublished data).

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193 km away seven months later; another banded in South Australia was recorded 262 km away, then later found dead only 8 km from the banding site (Purchase, 1969). Young birds are most likely to disperse beyond the normal limits of distribution, and Serventy *et al.* (1971) noted that recent sightings of Pacific Gulls in the Sydney area were of immature birds in the winter months. Similar movements occur in Tasmania where Liddy (1969) banded 82 birds on islands off Cape Portland: three were found dead on their natal islands and four were recovered between 100 km and 233 km away from the place of banding 4-12 months later. Young birds colour-banded in the Furneaux Group have been sighted at Flinders Island, Launceston, Burnie, Coles Bay and Lauderdale and Bellerive near Hobart (Robertson, pers. comm., 1981).

The main feeding sites of the Pacific Gull are sandy and rocky shores, bays and tidal flats. Simpson (1972) states that they often follow coastal shipping in Bass Strait, and they have apparently always been common around the docks of Hobart (Sharland and Crane, 1922; Harris, 1980). They occasionally move inland; an exceptional case occurred about 240 km inland at Beaudesert in New South Wales in 1885 and 1886 when Pacific Gulls appeared on the local rivers and dams (McGill, 1955). They have also been recorded along the Murray River (Condon, 1975). In Tasmania Littler (1910) indicated that they once wandered up the valley of the North Esk River near Launceston, and in recent years a Pacific Gull has been sighted at Mt. Nicholas near St. Marys about 15 km inland (Newman, 1971). They are more likely to move a short distance behind the cliffs and dunes of the coast: quite large flocks have been seen feeding on open ground at Phillip Island (Simpson, 1972), and Flinders Island (Wakefield, pers. comm., 1981). They are also attracted to rubbish tips (see Section 4.1) but are largely restricted to the tips closest to the coast; Simpson (1972) reported only one sighting of a pair of adults at a tip as far as 8 km inland from Port Phillip Bay.

Pacific Gulls have an essentially diurnal feeding pattern, although they have been reported to hawk over rookeries of White-faced Storm-petrels (*Pelagodroma marina*) on moonlit nights (Littler, 1910; Wakefield, pers. comm., 1981). There is little information on the night-time roosting sites. Sedgewick and Sedgewick (1950) concluded that most Pacific Gulls in the Esperance area of Western Australia roosted on rocks off the shore, and in Hobart, Wall (1973) noted that Pacific and Kelp Gulls roosted on the bases of the piers of the Tasman Bridge. We have also recorded them roosting on a breeding island and on the water in a bay, each time in company with large flocks of Kelp Gulls.

The Pacific Gull also requires daytime loafing sites which are generally elevated and are surrounded by water or have a clear view around them. Gulls may occupy these sites at any time of day in the Hobart area, but they are used most frequently at high tide when feeding sites are not exposed. Favoured loafing sites include wharves, posts, beacons and the masts of boats (Sharland, 1956; Simpson, 1972). The sites used in the Hobart area are analysed in Section 4.3. These types of loafing sites are generally not available at rubbish tips, so Pacific Gulls usually rest on open loafing areas shown in Section 4.2.1.

The Pacific Gull is primarily a shoreline and surface feeder, but has also been reported to plunge-dive from about 1 m above the water (Serventy *et al.*, 1971), to "puddle" the substrate with the feet to force organisms to the surface (Tarr, 1961), and to steal food from Silver Gulls (Sharland, 1958), Eastern Curlews (*Numenius madagascariensis*) and Sacred Ibis (*Threskiornis molucca*) (Dann, 1979) and Black-faced cormorant (*Phalacrocorax fuscescens*) (Wakefield, pers. comm., 1981).

One aspect of feeding behaviour which has received a disproportionate amount of attention is the Pacific Gull's habit, shared by other *Larus* gulls (Kent, 1981), of dropping prey items to open them. References to this behaviour in the Pacific Gull have been reviewed by Farr (1978). The usual prey items are shellfish, and some favoured rocky localities can have piles of shells large enough to be mistaken as ancient beach deposits (Teichert and Serventy, 1947). Wheeler (1946) reported that they even used a road near Melbourne as a dropping site, dodging cars to retrieve their prey. Tarr (1978) found that prey dropping occurred only when there was at least a moderate wind, allowing the birds to take off into the wind and climb steeply, and the technique was not very efficient because the prey items were dropped indiscriminately onto substrates of rock, sand or water. Items falling into the water were not usually recovered, although Wheeler (1943) noted that they were quickly retrieved from shallow water. Studies of similar behaviour in Kelp Gulls (Siegfried, 1977) and Herring Gulls (Kent, 1981) found that a fall onto sand was sufficient to break or stun bivalve molluscs; dropping onto rocks is capable of breaking very robust gastropod molluscs such as *Turbo* sp. (Serventy and Whittell, 1976). Other studies have suggested that the behaviour is simply play, when the bird may swoop down to catch the item before it strikes the substrate (Wheeler, 1943; Tarr, 1961). Our limited observations of prey-dropping confirms aspects of these previous studies. The behaviour was seen only in windy conditions and the birds ascended into the wind, which would be expected to minimize the energetic costs of the activity. An adult was observed dropping a crab (*Cancer novaezelandiae*) onto sand several times, and a number of first-year birds were seen together apparently playing with pieces of sheep or cow dung which they repeatedly dropped onto a paddock, sometimes catching the pieces as they fell, while adults rested nearby.

(b) Social behaviour

The social organization of the Pacific Gull has not been determined. They can occur singly, in pairs or in groups up to large flocks (Simpson,

1972) and are probably best described as loosely gregarious. Adults, either singly or in pairs, occupy feeding territories in the bays around Hobart and exclude other Pacific Gulls from them (see Section 4.3). Larger aggregations probably form when a site is attractive for feeding: Liddy (1969) recorded about 150 Pacific Gulls, mainly first-year birds, on the estuary at Bridport, and we recorded 351 Pacific Gulls at one rubbish tip. Aggregations will also form at roost sites (e.g. Sedgewick and Sedgewick, 1950), and in shelter from adverse weather (Simpson, 1972).

Social interactions of the Pacific Gull have not been studied systematically and do not permit any detailed comparison with other *Larus* gulls. There have been some isolated references to visual displays. Watson (1955) provided a description of two adult birds walking parallel to each other with their bills lowered to the sand and wings dropped, then one attacked by seizing the other's wing and some chases followed. Tarr (1961) referred to a stiff neck-arched posture adopted by adults (males ?) followed by a grass-pulling threat display (see Tinbergen, 1959) in territorial disputes on breeding islands. Serventy *et al.* (1971) reported a bowing display followed by an upward thrust of the head. Another posture, apparently unique to the Pacific Gull, that we have commonly observed is seen after a dispute, usually when one bird returns to its mate: the wings are held half-open and the head is raised and tilted slightly upwards (see Figure 3.7). Pacific Gulls also exhibit "choking" (see Tinbergen, 1959) in pairs.

The vocalizations of the Pacific Gull have been said to most resemble those of the Great Black-backed Gull (Serventy *et al.*, 1971). Table 3.3 presents a classification and summary of the vocal repertoire of the Pacific Gull determined during this study from observations of natural and man-made feeding sites during winter, and from observations and recordings made from a hide on a breeding island in November. Isolated references to calls are included in the table where they correspond to this arrangement. From this limited work it appears that Pacific Gulls have a minimum repertoire of seven distinct calls. It is notable that no calls correspond to the long call with its characteristic posture typical of other large white-headed *Larus* gulls (see Tinbergen, 1959).

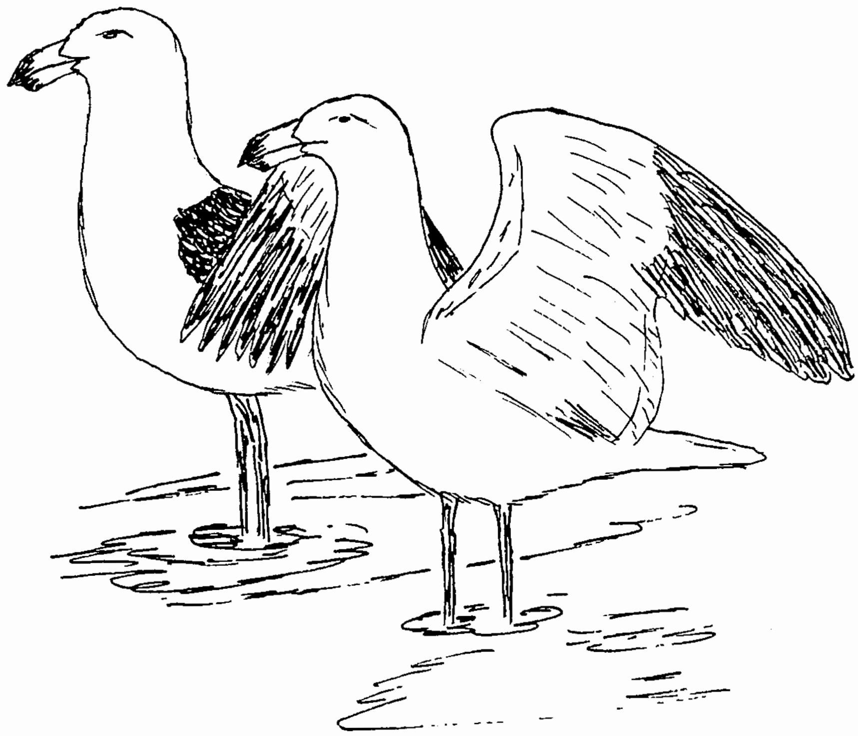
TABLE 3.3

The Vocal Repertoire of the Pacific Gull

Call	Sound	Description	Caller	Location	Context
Alarm	'hoh'	loud, long falling note	adult	in air	disturbance of colony (Serventy *et al.*, 1971) during bowing display (Serventy *et al.*, 1971)
Pair	'aw'	soft, level note 1-50 times	adult	on land & water	approach to mate; separated from mate; during copulation
Landing	'wark'	harsh, rising note 1-3 times	adult	in air	landing at nest, often with nesting material
Laugh	'oh oh'	2 short notes, sometimes 1 or 3	adult & imm.	in air, on land	hawking at night (Littler, 1910); circling over breeding colony; hovering over tip face; sometimes after pair call
Choking	'wu wu'	rapid notes, about 6 times	adult	on land	during choking display (see Tinbergen, 1959)
Charge	'oo-waah'	loud & harsh	imm.	in air	flying at or after other gulls
Beg	'wheee'	soft, high-pitched	imm.	on land	begging food from adults

FIGURE 3.7

The Wing-Out Display given by Pacific Gulls



3.2.5 Diet

The natural food of the Pacific Gull has not been studied in any detail. Table 3.4 lists the food items which have been reported in the literature, indicating a wide range of possible foods. An ornithological bias is evident in the literature, since the only prey species covered in any detail are birds. Carrion (i.e. dead beach-washed organisms) are grouped with offal from fishing because they are difficult to distinguish unless the original source of the food is known. Further details of diet are given in Appendix 1.

TABLE 3.4

Food Types Recorded for the Pacific Gull

Food Type	Reference
PLANTS	
African Boxthorn (fruits), *Lycium ferocissium*	g
Saltbush (fruits), *Rhagodia* sp.	x
Noonflower (fruits), *Carpobrotus* sp.	x
INVERTEBRATES	
Insects	w
Fly larvae	v
Echinoderms	kly
Molluscs	
Cephalopods:	
Cuttlefish	w
Squid	y
Gastropods	kw
Warreners (*Subninella*)	dlpy
Limpets	dl
Bivalves:	w
Mussels	dqst
Chitons	duy
Crustaceans	p
Crabs	bcdkpwy
"worms and insects"	o
"grubs and worms"	f
VERTEBRATES	
Fish	dpqwy
Sea horse, *Hippocampus*	y
Birds	
Fairy Prion, *Pachyptila turtur*	i
White-faced Storm-petrel, *Pelagodroma marina*	afw
Common Diving-Petrel, *Pelecanoides urinatrix*	adg
Little Shearwater, *Puffinus assimilis*	k
Short-tailed Shearwater, *Puffinus tenuirostris*	dekr
Australian Gannet (young), *Morus serrator*	n
Silver Gull, *Larus novaehollandiae*	m

Table 3.4 Contd.

Table 3.4 Continued

Food Type	Reference
VERTEBRATES	
Birds (Continued	
Sooty Oystercatcher (eggs), *Haematopus fuliginosus*	x
Cape Barren Goose (eggs), *Cereopsis novaehollandiae*	j
"small quadrupeds"	b
CARRION AND FISHING OFFAL	bloqsy

a. Brothers (1980).
b. Gould (1865).
c. Jones (1979).
d. Jones and Allen (1978).
e. Liddy (1969).
f. Littler (1910).
g. Mirtschin (1981).
h. Naarding (1981).
i. Norman *et al.* (1980).
j. Pearse (1975).
k. Serventy *et al.* (1971).
l. Serventy and Whittell (1976).
m. Sharland (1956)
n. Sharland (1958).
o. Simpson (1972).
p. Sutton (1935).
q. Tarr (1961).
r. Warham (1979).
s. Watson (1955).
t. Wheeler (1946)
u. Davis (pers. comm., 1981).
v. Harris (pers. comm., 1981).
w. Wakefield (pers. comm., 1981).
x. Robertson (pers. comm., 1981).
y. This study (see Appendix 1).

The Pacific Gull also utilizes sources of food which are clearly of human origin. In general they are regarded as less "aggressive" than Silver Gulls when in the proximity of humans (Serventy *et al.*, 1971), but there is an intriguing observation of Pacific Gulls fighting for scraps with Silver Gulls in the backyards of Ceduna, South Australia in 1907 (Sutton, 1935). Early observers noted that Pacific Gulls had a propensity to feed on refuse thrown overboard from vessels, particularly when in port (Littler, 1910; Sutton, 1935; Sharland, 1958).

Pacific Gulls also feed at rubbish tips. In Tasmania, Liddy (1969) noted that up to 50 birds often fed at the Launceston tip, and Thomas (1967) stated that six or more Pacific Gulls could commonly be seen in the area of Sorell tip. During 1981 we recorded Pacific Gulls at eight tips in northern and southern Tasmania (see Section 4.1). They have also been recorded at the Whitemark tip on Flinders Island by Robertson (pers. comm., 1981). In Victoria they feed at tips close to Port Phillip Bay (Simpson, 1972; Robertson, pers. comm., 1981) and Westernport Bay (Loyn, 1978; Robertson, pers. comm., 1981), and also at the tip on Wilson's Promontory (Robertson, pers. comm., 1981). Pacific Gulls occur only occasionally in New South Wales and apparently do not visit tips there (Gibson, pers. comm., 1981). No information is available for South Australia. In Western Australia the Pacific Gull feeds at the Esperance tip in company with the Kelp Gull (Cooke, pers. comm., 1981), and up to 60 Pacific Gulls feed at the Carnarvon tip (Thomas, pers. comm., 1981).

3.2.6 Reproduction

The Pacific Gull generally nests as solitary pairs or in loose colonies in the Furneaux Group, where the nest density is apparently largely determined by the type of vegetation (Robertson, pers. comm., 1981). Tarr (1961) regarded 50 yards (approximately 50 m) as a minimum distance between neighbouring nests, but Liddy (1969) reported distances ranging from 3-31 yards between nests in a line on Baynes Island in Tasmania. A widely accepted measure of nest spacing is the nearest neighbour distance (after Patterson, 1965); when Liddy's data are calculated on this basis, the mean nearest neighbour distance is approximately 9 m. By contrast, Pacific Gulls formed a tight colony with a mean nearest neighbour distance of 2.5 m where it nested with Kelp Gulls on Green Island in 1981 (Coulson *et al.*, in prep.).

Nests tend to be sited in elevated areas such as small rises or along ridges (Tarr, 1961; Liddy, 1969), but they may also be situated on flat terrain (Liddy, 1969). The amount of cover required appears to be quite variable: Liddy (1969) stated that most nests were constructed in tussocks, but could also be in clear areas, in short grass or against rocks. Wakefield (pers. comm., 1981) found that many nests in the Furneaux Group were at the base of rocks which then served as lookout posts. Nests on Green Island were beside tussocks and shrubs, and in dense clumps of tall thistles (Coulson *et al.*, in prep.).

The nest is a fairly substantial structure made of the plant material available; Tarr (1961) lists sticks, flower stalks and grasses with a lining of finer material, and Serventy *et al.* (1971) include the flower stalks and seed heads of several plant genera. Typical nest dimensions for external width and bowl depth respectively, have been recorded as: 20-25 cm and 6-8 cm (Liddy, 1969); 23 cm and 8 cm (Tarr, 1961; 25 cm and 13 cm (Serventy *et al.*, 1971).

The Pacific Gull breeds in spring and summer. The timing of territory formation and nest construction is unknown, and egg-laying depends on the locality. Serventy and Whittell (1971) stated that eggs have been recorded in early October in the Abrolhos Group, Western Australia, but Bush (pers. comm.) has reported eggs in late August on islands off the south coast of Western Australia. In the higher latitudes of Tasmania, where egg-laying would be expected to begin later, Liddy (1969) recorded eggs from 21 October on the islands off Cape Portland and the first eggs were laid on Green Island near Hobart on 14 October ± 3 days (Coulson *et al.*, in prep.).

The usual clutch size is 2 or 3 eggs (Serventy *et al.*, 1971). Liddy (1969) describes the colour of the eggs as "... olive-brown, with brown and grey-purple blotches and spots". The weight and dimensions of eggs are given in Table 3.5. Typical dimensions for Tasmanian eggs are: length 74-75 mm, width 51 mm, weight 99 g.

TABLE 3.5

Length, Width and Weight of Pacific Gull Eggs

Reference	Location	Measurement	Mean	Standard Deviation	Range	Sample Size
Tarr (1961)	W.A. and Tas.	Length (mm)	74			12 clutches
		Width (mm)	52			12 clutches
Liddy (1969)	Baynes and MacLean Islands, Tas.	Length (mm)	74.4	2.1	71.4-78.9	19
		Width (mm)	51.1	1.0	49.6-53.5	19
Serventy *et al.* (1971) Serventy and Whittell (1976)	W.A.	Length (mm)	76		65-81	26
		Width (mm)	51		49-54	26
		Weight (g)	90		70-105	26
Coulson *et al.* (in prep)	Green Island, Tas.	Length (mm)	74.5	2.1	69.4-79.5	60
		Width (mm)	51.2	1.3	48.1-54.9	60
		Weight (g)	99	5	90-111	60

The eggs are incubated by both parents according to Wakefield (pers. comm., 1981) and Tarr (1961) gives the incubation period as 26-28 days. The downy chicks are well camouflaged with irregular brown spots on a buff-coloured background (Tarr, 1961). They remain in the nest for about 3 or 4 days, then move to cover such as tussocks nearby during disturbance. As they grow they are more likely to escape by running, and chicks nearly fledged tend to take to the water according to Liddy (1969). However, Brothers (1980) reported young birds hiding under tussocks even though they were capable of flight, and Harris (pers. comm., 1981) has found that young Pacific Gulls are far more reluctant to enter the water than are young Kelp Gulls. The young are fed regurgitated food mainly by one parent, and they are fledged at about eight weeks of age (Tarr, 1961).

3.2.7 Population

(a) Natality and mortality

Pacific Gulls are not likely to breed before they attain full adult plumage (see Section 3.2.2). However, there is no information on the timing of sexual maturity or the age of recruitment into a breeding population.

The longevity of Pacific Gulls is also unknown. Adults are probably immune to predation, but there are a number of potential predators of eggs and young, such as raptors and ravens (Brothers, 1980). Liddy (1969) noted adult Caspian Terns (*Hydroprogne caspia*) repeatedly attacking a newly-fledged Pacific Gull on the water, and similar behaviour by adult Kelp Gulls has been reported by Harris (pers. comm., 1981). From studies in the Furneaux Group, Robertson (pers. comm., 1981) has found that the survival rate of young up to fledging has varied from approximately 30-65%. Post-fledging mortality rates are not known, but most band returns come from birds in their first year. One cause of mortality at this stage appears to be "misadventure": band recoveries have come from one bird which had choked on a fish, from a second tangled in fishing line (Liddy, 1969) and another drowned in a fishing net (Harris, pers. comm., 1981).

(b) Population size

There is very little population data available for the Pacific Gull. Some population counts have been made over short time intervals in specific areas during general bird surveys. For example, McGarvie and Templeton (1974) reported up to 50 Pacific Gulls in Burgess Bay on King Island, and Loyn (1978) recorded a maximum of 705 in Westernport Bay in Victoria. A few studies (e.g. Sedgewick and Sedgewick, 1950; Watson, 1955) also indicate the broad age structure of the birds present by giving the proportion of birds in different plumage phases. Surveys of this type are valuable in establishing base-line data against which population changes can be assessed, but they contribute little to an estimate of total population size. Probably a more reliable approach is to estimate the number of breeding pairs. There are no known breeding colonies in New South Wales (Lane, 1979), Victoria has an estimated breeding population of 400 pairs (Harris and Norman, 1981), but Tasmania, South Australia and Western Australia have not been fully surveyed although a number of individual islands have been studied in detail.

The only attempt to obtain an estimate of absolute population size in a fairly large area has been by the Bird Observers Association of Tasmania which has conducted a census of large gulls in south-east Tasmania. Counts were made early in June 1980 and 1981 and involved a simultaneous coverage of the coastline by a team of observers. Although the surveys were aimed primarily at the Kelp Gull and covered areas where they were likely to be encountered, any Pacific Gulls in these areas were also recorded. Many bays and beaches which would be expected to have Pacific Gulls were not surveyed, so the census could provide only a minimum estimate for the total Pacific Gull population in the region. The results of the census are summarized in Table 3.6. The areas covered were changed slightly in the second year, but a goodness of fit Chi-square test of the totals for only the areas searched in both years indicated that there was no difference between the two annual totals. The census will be conducted again in 1982.

TABLE 3.6

Minimum Population Size for the Pacific Gull in South-east Tasmania, from the Bird Observers Association of Tasmania June Census of Large Gulls

Year	Count for areas searched in both years	Count for all areas
1980	222	266
1981	215	239

3.2.8 Status

In the absence of comprehensive population data, the status of the Pacific Gull in Australia cannot be determined precisely, although some generalizations can be made about its present status and some apparent changes in status since the beginnings of European settlement. Each state is considered separately.

(a) Queensland

The Pacific Gull was reported to be "rather plentiful" on the central and north-east coasts of Queensland in the nineteenth century, extending as far north as Rockhampton (McGill, 1955). But less than eighty years later McGill (1955) concluded that it was a rare bird in Queensland. It must still be considered rare with only occasional sightings in south-east Queensland (Vernon and Filmer, 1972) and north-east Queensland (see Figure 3.5).

(b) New South Wales

The Pacific Gull appears to have undergone a similar decline in New South Wales. An analysis by McGill (1955) of contemporary accounts indicated that the status of Pacific Gull along the coast changed from "common in all the bays and inlets" in 1898 to being extremely rare by 1916. The Field Atlas map (Figure 3.5) shows sightings along the New South Wales coast, but the only regular sightings are made on the far south coast (Rogers, pers. comm., 1981). The species is not known to breed on any islands in the state (Lane, 1979).

(c) Victoria

Wheeler (1967) considered the Pacific Gull to be "moderately common" in Victoria. No Victorian breeding colonies were listed by Serventy *et al.* (1971) probably due to a lack of observers, although Harris and Norman (1981) recording breeding colonies on Phillip Island in Westernport Bay and on islands off Wilsons Promontory.

(d) South Australia

Boehm (1961) stated that the Pacific Gull "could hardly be regarded as a very numerous species in South Australian waters", and suggested that the population had declined in the preceding 50 year period. Condon (1969) considered that the species was most common around Kangaroo Island and Eyre Peninsula but rare in St. Vincent Gulf.

(e) Western Australia

The Pacific Gull is relatively common in the Esperance and Albany regions (Johnstone, pers. comm., 1982), and around Carnarvon (Thomas, pers. comm., 1981). It is less common along rocky coastlines such as the Great Australian Bight (Serventy *et al.*, 1971). Serventy and Whittell (1976) suggested that the Pacific Gull had extended its range north from Shark Bay to Point Cloates early this century, possibly in response to the establishment of the Point Cloates whaling station, although it ceased operations in 1928. The uniformly distributed sightings made in recent years further north than Point Cloates (see Figure 3.5) suggest that this expansion may still be continuing.

(f) Tasmania

Gould (1865) stated that the Pacific Gull was "abundantly dispersed over all the shores of Tasmania (and) the islands of Bass's Straits". It has remained relatively common in Tasmania, and the Bass Strait islands are probably its stronghold (Simpson, 1972). Sharland and Crane (1922) classified it as "very common" around the harbour of Hobart, and Harris (1980) reported that it is still commonly seen in the same area, although Sharland (pers. comm., 1981) believes that it has declined somewhat. The Pacific Gull has been sufficiently common in the past to be regarded as a pest of the muttonbird industry in Tasmania. Prior to 1957, it was partly protected, with an open season from 1 November to 31 May which corresponds to the period the muttonbird (*Puffinus tenuirostris*) spends at its breeding colonies (Naarding, 1980). In 1957 even this partial protection was removed because Pacific Gulls were seen as becoming serious predators of muttonbirds (Liddy, 1969), but in 1971 they were given total protection when the National Parks and Wildlife Service was created. Despite this formal protection, it is likely that some gulls are still shot as pests, particularly in the Furneaux Group; for example, Davis (pers. comm., 1981) recorded numerous carcases of adult Pacific Gulls on Cat Island in 1980.

In overall terms, the Pacific Gull thus seems to be secure in Australia. In Western Australia it has apparently extended its range northwards, but on the eastern coast it has suffered a significant reduction in range. It is possible that its decline in the eastern states may be the result of increased industrialization and urbanization in these large population centres. This interpretation would seem to be contradicted by its common status in the large human population centre of Port Phillip Bay, but gull numbers there could be maintained by immigration from the Bass Strait islands. The low human population densities in Tasmania and Western Australia correspond with the areas where Pacific Gulls are most common. An alternative, although perhaps related, hypothesis is that the population growth of Silver Gulls has produced increased competition for food and Pacific Gull numbers have declined as a result (Sharland, pers. comm., 1981). Whatever the reason, it is clear that these changes were underway long before the arrival of the Kelp Gull in Australia.

3.3 The Kelp Gull

3.3.1 Classification

The Kelp Gull (*Larus dominicanus* Lichtenstein) is also known as the Dominican Gull or Southern Black-backed Gull, but Schodde *et al.* (1978) recommended Kelp Gull as the standard name to be used in Australia. The name Kelp Gull also has wide currency in South Africa and South America (although not in New Zealand or in the Antarctic) and this convention is followed in this report.

The Kelp Gull was first described in 1823 from a specimen collected in Brazil (Condon, 1975). Initially its extensive distribution in the Southern Hemisphere (see Section 3.3.3) and the degree of geographical and individual variation in its morphology resulted in confusion with other species and the description of geographical races as additional species. Some examples are given by Kinsky (1963): specimens from South Georgia were mis-identified as Great Black-backed Gulls at first, and separate species were described from South Africa and New Zealand. The Kelp Gull clearly belongs in Moynihan's (1959) group of large white-headed gulls on the basis of external and behavioural similarities. This group also includes the Pacific Gull (see Section 3.2.1). The arrangement was confirmed by a study of the behavioural repertoire of the Kelp Gull by Fordham (1963) who concluded that its behaviour patterns were practically identical with those of the Herring and Lesser Black-backed Gulls, which are the most comprehensively studied members of the group (see Section 3.3.4). Various authorities have suggested that the Kelp Gull is most closely related to the Herring Gull (Falla, 1937), the Lesser Black-backed Gull (White, 1952) or the Great Black-backed Gull (Oliver, 1974). More recent studies of morphology (Schnell, 1970a,b) and vocalizations (Hand, 1981) indicate that the Kelp Gull may have its closest affinities with the Western Gull.

Kinsky (1963) concluded that no subspecies of the Kelp Gull could definitely be distinguished. However, Brooke and Cooper (1979a) have recently described a South African subspecies, *Larus dominicanus vetula*, which differs from other populations in iris colour and body size. There is no evidence from band returns of movements into or out of South Africa but Brooke and Cooper reported a sighting off the western coast of South Africa of a flock of Kelp Gulls which were assumed to be visitors from the Antarctic Peninsula because they differed in iris colour (and other characteristics) from the resident *L. d. vetula* and did not interact with them. Although iris colour has been shown to be an important isolating mechanism in closely-related northern hemisphere gulls (Smith, 1966), Brooke and Cooper resisted the temptation to elevate the South African race to full species status. Pending further sub-divisions, all other Kelp Gull populations, including the one in Australia, must be included in the nominate race, *L. d. dominicanus*.

3.3.2 Description

The Kelp Gull is similar in size to the Herring Gull and Lesser Black-backed Gull, and is noticeably smaller than the Pacific Gull. Tuck (1980) gives its dimensions as: length 58 cm, wind-span 127 cm. The mean body weight, extracted from museum records, was 916 g for ten specimens collected in the Hobart area. This value is 75% of the weight given for Pacific Gulls in Section 3.2.2. Like the Pacific Gull, the Kelp Gull shows sexual dimorphism in body size. There were insufficient data from Tasmanian specimens to demonstrate this clearly, but Kinsky (1963) reported mean weights for adult New Zealand birds as 1050 g for males and 832 g for females. There is also sexual dimorphism in bill size. Table 3.7 summarises bill measurements from populations in widely separated areas of the Kelp Gull's distribution (including the limited data for Tasmania) which show that, within a population, males have bills which are deeper at the gonydeal angle and have a greater culmen length (see Figure 3.3). These differences are sufficient to permit the sexes of paired birds to be distinguished in the field.

TABLE 3.7

Mean and Range of Bill Measurements for Separate Populations of the Kelp Gull

Population and Reference	Adult Males			Adult Females		
	Sample Size	Culmen (mm)	Gonys (mm)	Sample Size	Culmen (mm)	Gonys (mm)
New Zealand (Kinsky, 1963)	57	53.9 (49.0-59.0)	21.8 (19.5-23.5)	55	49.2 (44.5-53.0)	19.6 (18.0-21.5)
Several Sub-Antarctic Islands (Kinsky, 1963)	6	50.8 (49.5-53.0)	21.7 (20.5-22.5)	9	45.5 (43.5-48.0)	19.4 (18.0-20.5)
Marion Island (Brooke and Cooper, 1979a)	8	50.3 (46.0-54.0)	19.3 (18.0-21.0)	7	45.0 (43.0-48.0)	18.2 (17.0-18.5)
South Africa (Brooke and Cooper, 1979a)	13	57.4 (54.0-61.5)		25	52.5 (50.0-54.5)	
Tasmania (this study)	3	54.6 (50.8-58.3)	21.4 (21.0-21.6)	2	48.8 (47.5-50.0)	19.4 (18.8-20.0)

The Kelp Gull undergoes progressive changes in appearance with age. The changes in plumage and soft parts have been comprehensively studied in New Zealand birds by Kinsky (1963) who found that the species has a five-year moult cycle, comprising four years of almost continuous full or partial moult through immature phases then a stabilized annual moult cycle in the fifth and subsequent years. Table 3.8 summarizes Kinsky's descriptions for each age class.

TABLE 3.8

A Summary of Typical Colouration of Plumage and Soft Parts for each Age Class of New Zealand Kelp Gulls (from Kinsky, 1963)

Year	Selected features	Colouration
First	back and mantle	dark brown earlier to grey brown later
	head, neck and underside	brown to grey, with white streaks
	tail	black, mottled at the base
	bill	black, often with light tip later
	legs and feet	red-brown to dark brown
	eye ring	grey
	iris	very dark brown
Second	back and mantle	brown earlier to black later
	head, neck and underside	brown with white streaks to white with brown streaks
	tail	black and white (retains some black)
	bill	light with black markings, or yellow with orange spot later
	legs and feet	grey earlier to bluish grey later
	eye ring	light yellow earlier to reddish-orange later
	iris	light brown earlier to light grey later
Third	back and mantle	black
	head, neck and underside	white with some brown streaks
	tail	white, sometimes with small black patches
	bill	light yellow with pale red spot or black marking earlier
	legs and feet	bluish grey to greenish grey
	eye ring	orange
	iris	pale grey, or light brown earlier
Fourth	Most birds indistinguishable from adults - see text	
Adult	back and mantle	black
	head, neck and underside	white
	tail	white
	bill	rich yellow with deep red spot
	legs and feet	greenish grey to bright yellow
	eye ring	red-orange
	iris	pearl grey

Early in their first year, Kelp Gulls are dark brown with a pattern of buff markings on the wings, and a black bill (see Plate 3.3). Birds at this stage are most difficult to distinguish from young Pacific Gulls in the field, particularly those which have retained an entirely dark grey bill.

PLATE 3.3

Juvenile Kelp Gull

PLATE 3.4

Adult Kelp Gull

They can best be distinguished by relative differences in bill size and shape (see Figure 3.3), and by the paler head and neck of the Kelp Gull compared with the dark brown colouration of the young Pacific Gull referred to in Section 3.2.2. During the first year, the Kelp Gull loses the buff patterning on the wings, and the feathers of the head, neck and ventral surface become much greyer. At this stage young Kelp Gulls were found to be readily distinguished from Pacific Gulls of the same age at considerable distances in the field by reference tothe pale grey-brown plumage of the Kelp Gull compared with the dark brown of the Pacific Gull, particularly on the head and neck.

The changes which take place in the second year are highly variable. Kinsky (1963) found that some retarded birds may appear very similar to late first-year birds whereas advanced birds can resemble adults. Similar variations occur in the third year when retarded birds retain some degree of brown mottling in the white feathers and advanced birds appear very similar to adults. The majority of birds in their fourth year are indistinguishable from adults, but some revert to the streaked appearance of most third-year birds.

All Kelp Gulls have attained the adult colouration in their fifth year (Plate 3.4). The plumage is pure black on the back and most of the wings, and pure white elsewhere as shown in Figure 3.4. By comparison with the Pacific Gull, the white wing margins are wider in the Kelp Gull and extend the full length of the trailing edge of the wing. Figure 3.4 shows a single sub-terminal mirror only on the tenth primaries, but Kinsky (1963) notes that a second mirror is present on the ninth primary of 40% of adult New Zealand birds. The all-white tail of the Kelp Gull is generally sufficient to distinguish the two species in flight, although Robertson (1977) has noted that some confusion has resulted from the absence of a black sub-terminal band in Pacific Gulls which had shed their tail feathers during a post-breeding moult. Adults of the two species can also be distinguished by bill and leg colour. Adult Kelp Gulls have a yellow bill with a red gonydeal spot whereas the red area is more extensive (see Figure 3.3) and the remainder of the bill is more orange-yellow in the Pacific Gull. The legs and feet of adult Kelp Gulls range from greenish or even bluish-grey to rich yellow which intensifies at the beginning of the breeding season (Kinsky, 1963), whereas adult Pacific Gulls have more orange-yellow legs and feet.

Some rare colour aberrations have been recorded in the Kelp Gull: a dark hood and nearly black bill on a bird with otherwise adult plumage (Kinsky, 1963), a near albino with a few fawn markings (McLintock, 1959), adult birds with conspicuous white patches on the upper surface of each wing (Kinsky, 1963; Dillingham, 1972; Jehl, 1973), and a grey-mantled adult (Jehl, 1973).

3.3.3 Distribution

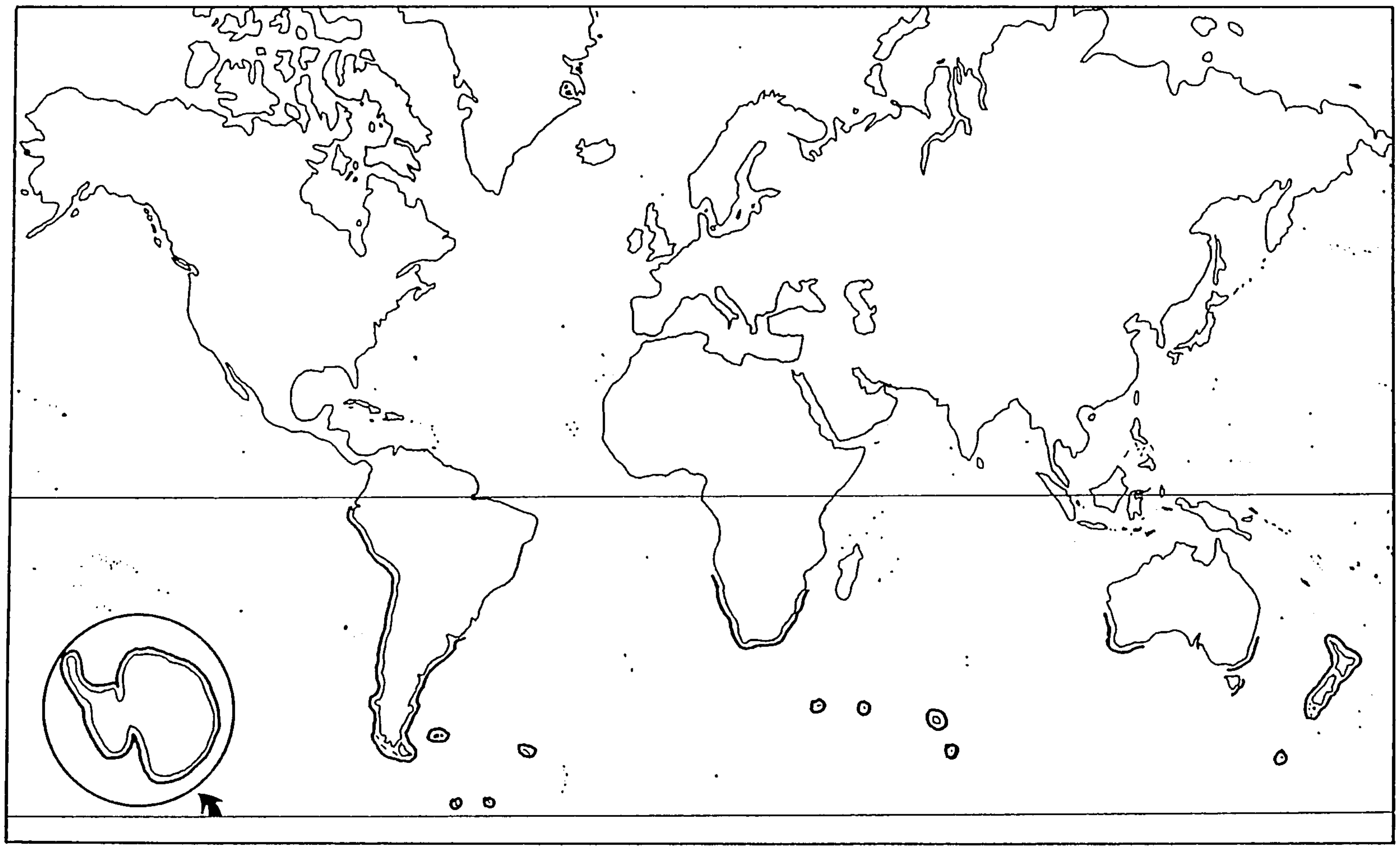
The Kelp Gull has a circumaustral distribution as shown in Figure 3.8. It occurs on the coasts of all the southern continents, including Antarctica, and on the sub-antarctic islands (Watson, 1975). On the Antarctic continent it breeds only on the Antarctic Peninsula to about 68° S (Watson, 1975), but has been recorded as far south as 78° S at Cape Royds (Spellerberg, 1965). It also breeds on most of the sub-antarctic islands (Tuck, 1980) with the significant exception of the Tristan da Cunha Group (Wace and Holdgate, 1976). In South America it has been recorded breeding north to Cape Frio (24° S) on the east coast, and as far north as Lobos de Tierra off Peru (6° S) on the west coast from where it occurs casually further north to the coast of Equador (Murphy, 1936). The Kelp Gull has also been recorded as a vagrant from the Galapagos Archipelago on the equator (Harris, 1975). In southern Africa the known breeding distribution extends from Cape Cross in Namibia (22° S) on the west coast around to Algoa Bay in South Africa (34° S) on the east coast, and the species probably also breeds in Madagascar (Brooke and Cooper, 1979a). Non-breeding birds extend at least as far north as Luanda (Angola) on the west coast, and to southern Mozambique on the east coast (Brooke and Cooper, 1979a). The Kelp Gull is widespread in New Zealand (Bull, 1971). It breeds throughout its range, forming colonies around the coastline and inland (Kinsky, 1963). It has also been recorded as a straggler to the Kermadec Islands and Norfolk Island (Falla *et al.*, 1979).

Prior to 1943, the Kelp Gull had not been reported in Australia. The first published sighting was made by McGill (1943) who observed a Kelp Gull in adult plumage at Botany Bay near Sydney in January and February 1943. The species was recorded again at intervals in the forties and early fifties both in New South Wales and Victoria, and McGill (1955) suggested that it was extending its range to eastern Australia. He commented:

> *The possibility that it may eventually breed there is not entirely remote.*

FIGURE 3.8

The Worldwide Distribution of the Kelp Gull, after Watson (1975) and Tuck (1980)



Only three years later breeding was first recorded on Moon Island near Sydney by Gwynne and Gray (1959). Since then the Kelp Gull has been recorded in all Australian states and additional breeding colonies have been located in New South Wales, Victoria and Tasmania. Table 3.9 summarizes the significant sighting records and first breeding records in each state. The timing of these early records suggests that the Kelp Gull spread southwards from the Sydney area to Victoria and Tasmania then westwards to Western Australia, with some stragglers reaching the other states. However, it is likely that these sightings also reflected the development of interest in the species. Sightings from each new locality tended to come in bursts. A combination of enthusiasm and lack of familiarity with the species resulted in some records of doubtful validity: Wood (1955) gave a highly ambiguous description of a gull at Geelong (Victoria) which has led Robertson (1977) to conclude that the bird was a mis-identified Pacific Gull, and the same conclusion could be drawn from McHugh's (1965) description of a gull at Esperance, Western Australia. Similarly, Boekel's (1976) record of two adult Kelp Gulls at Melville Bay in the Northern Territory has been re-interpreted by Van Tets (1977b) who concluded that they were actually Scandinavian Lesser Black-backed Gulls (*Larus fuscus fuscus*) which had not previously been recorded in Australia. However, Van Tet's arguments have been questioned by others (Close *et al.*, 1979; Curry, 1980) and it is more parsimonious to accept Boekel's record as an extension of range for the Kelp Gull.

It is clear that the Kelp Gull had been present in Australia, probably as occasional vagrants, before the first published sightings in New South Wales. Ford (1965) reported an early record of a Kelp Gull collected at Claremont, Western Australia in 1924. This specimen was a first-year bird which was originally mis-identified as a Pacific Gull. D'Ombrain (1973) later reported sightings of Kelp Gulls near Port Stephens and Newcastle (New South Wales) in 1938 and 1939, supporting the view that the species first became established in that region of Australia.

The origin of the Kelp Gulls which colonized Australia is uncertain. One possibility is that they escaped from zoos. Sutton (1935) reported that a colony of Kelp Gulls imported from South Africa was held at the Adelaide Zoo. One bird escaped wing-cutting in 1931 and used to fly around the district, leading to reports of it as a Pacific Gull. The records of the zoo were inadequate to determine the fate of this bird or the rest of the colony (Baker, pers. comm., 1981), but Australian Kelp Gulls do not belong

TABLE 3.9

A Summary of Significant Sighting Records and First Breeding Records of Kelp Gulls in Australian states

State	Significant sighting records	First breeding records
N.S.W.	Port Stephens, 1938 (D'Ombrain, 1973) Botany Bay, 1943 (McGill, 1943) Wollongong, 1953 (McGill, 1955) Five Islands, 1958 (Gibson and Sefton, 1962)	Moon Island, 1958 (Gwynne and Gray, 1959) Five Islands, 1968 (Battam, 1970)
Vic.	Avalon, 1953 (Wood, 1955)* Wilsons Promontory, 1954 (Wood, 1955) Geelong, 1954 (McGill, 1954)	Seal Rocks, 1971 (Warneke, pers. comm., 1981)
Tas.	Hobart, 1955 (Wall, 1956) King Island, 1972 (McGarvie and Templeton, 1974)	Curlew Island, 1963 (Wolfe, 1969) Barren Island, 1970 (Wall, 1970) Lachlan Island (Serventy *et al.*, 1971) Green Island, 1977 (Green, 1977) Visscher Island, 1979 (Jones, 1979)
S.A.	Adelaide, 1932 (Sutton, 1935)* Port Adelaide, 1968 (Glover, 1968) Ceduna, 1969 (Close, 1981)	
W.A.	Claremont, 1924 (Ford, 1965) Albany, 1963 (Ford, 1964) Jurien Bay, 1964 (Ford, 1964) Esperance, 1965 (McHugh, 1965)*	
Qld.	Cairns, 1969 (Gill, 1970; Jack, 1971) Southport, 1971 (Fien, 1971)	
N.T.	Melville Bay, 1974 (Boekel, 1976)*	

* - see text

to the South African subspecies (see below). Similarly, Hindwood and Cunningham (1950) suggested that McGill's (1943) original sighting may have been an escapee from Taronga Park Zoo in Sydney. However, McGill (1955) was assured that the birds there could not fly, and since the only Kelp Gull bred in the zoo was in 1944 it could not account for the first sighting in 1943 or a subsequent sighting of an immature bird in 1953.

The early sightings of Kelp Gulls in New South Wales were assumed to be of New Zealand birds which possibly had followed shipping across the Tasman Sea (McGill, 1943, 1955). The record of a Kelp Gull on Lord Howe Island (Hindwood and Cunningham, 1950) added support to this view. When the species was first recorded in Western Australia, Ford (1964) acknowledged that it had probably moved westward from eastern Australia and previously New Zealand, but added that it may instead have originated from the sub-antarctic islands to the south-west (e.g. Heard Island) assisted by the prevailing westerly winds. Subsequently, Ford (1965) found that the dimensions of the mis-identified 1924 specimen were above the range given by Kinsky (1963) for sub-antarctic populations but coincided with the upper limit of the range for the New Zealand population, and concluded that it had come from New Zealand. The bill dimensions of five adult Tasmanian Kelp Gulls are included in Table 3.7; in each case they lie within the ranges given for the New Zealand population, either within or above the ranges for sub-antarctic islands, and at or below the lower limits for the South African subspecies. In addition, eight immature birds collected in Tasmania had bill dimensions which fell within the range for New Zealand birds given by Kinsky (1963). It thus seems most likely that Australia's Kelp Gull population originated in New Zealand.

The present distribution of the Kelp Gull in Australia is shown in Figure 3.9. It is more restricted than the distribution of the Pacific Gull (Figure 3.5), extending from south-west Western Australia to south-east Queensland. The detailed distribution map for Tasmania (Figure 3.10) shows that it is concentrated in south-east Tasmania, but has also been recorded along the east coast and in some other isolated areas.

The breeding distribution in Australia is very restricted. The first records of new breeding colonies are documented in Table 3.9. At present the only known breeding colonies are: Moon Island and Bass, Flinders and Martin Islets of the Five Islands in New South Wales (Lane, 1979), Seal Rocks off Phillip Island in Victoria (Warnecke, pers. comm. 1981), and Green, Lachlan and Visscher Islands in Tasmania (Fletcher *et al.*, 1980). Breeding was first recorded in Tasmania on Curlew Island but it is not certain if they have bred there in recent years (Harris, pers. comm., 1981). Coulson *et al.* (in prep.) found no evidence of breeding in the 1981/82 season on Barren Island, which was the second site recorded in Tasmania. The locations of all the Tasmanian breeding colonies are shown in Figure 3.11.

FIGURE 3.9

The Distribution of the Kelp Gull (*Larus dominicanus*) in Australia, from the Royal Australasian Ornithologists Union Field Atlas Interim Printout (to 31 January 1981)

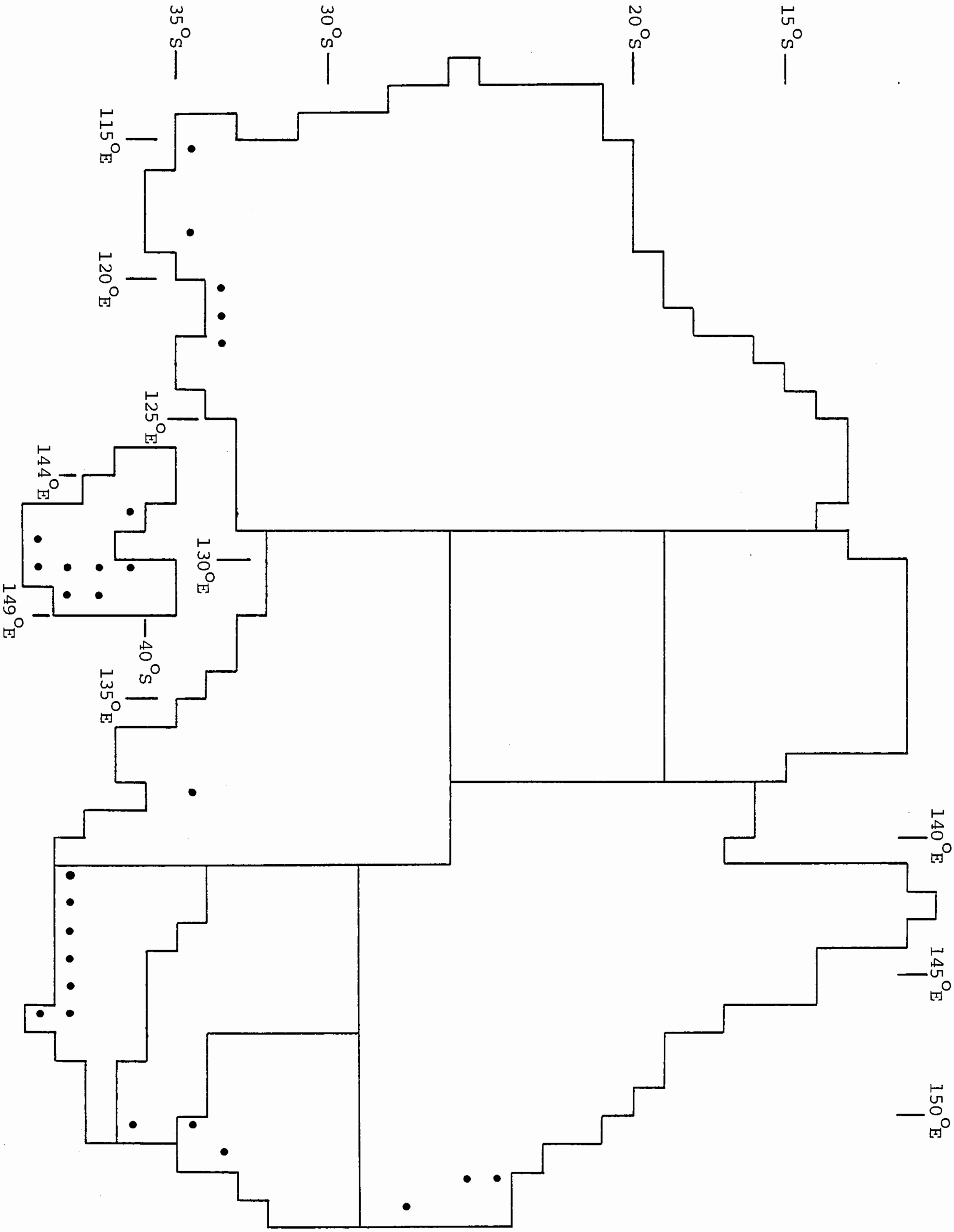


FIGURE 3.10

The Distribution of the Kelp Gull (*Larus dominicanus*) in Tasmania, from the Royal Australasian Ornithologists Union Field Atlas Interim Printout (to 31 January 1981)

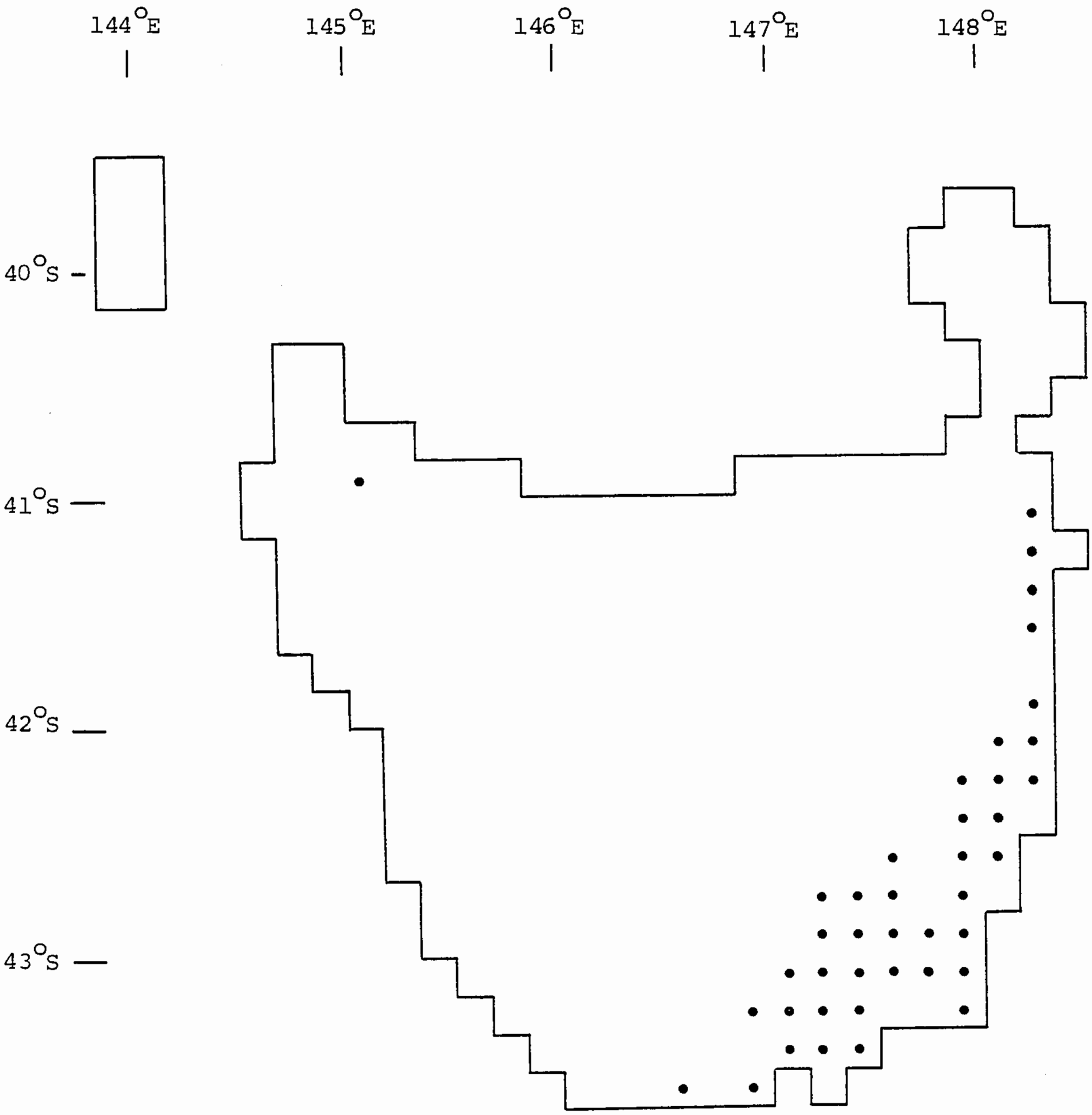
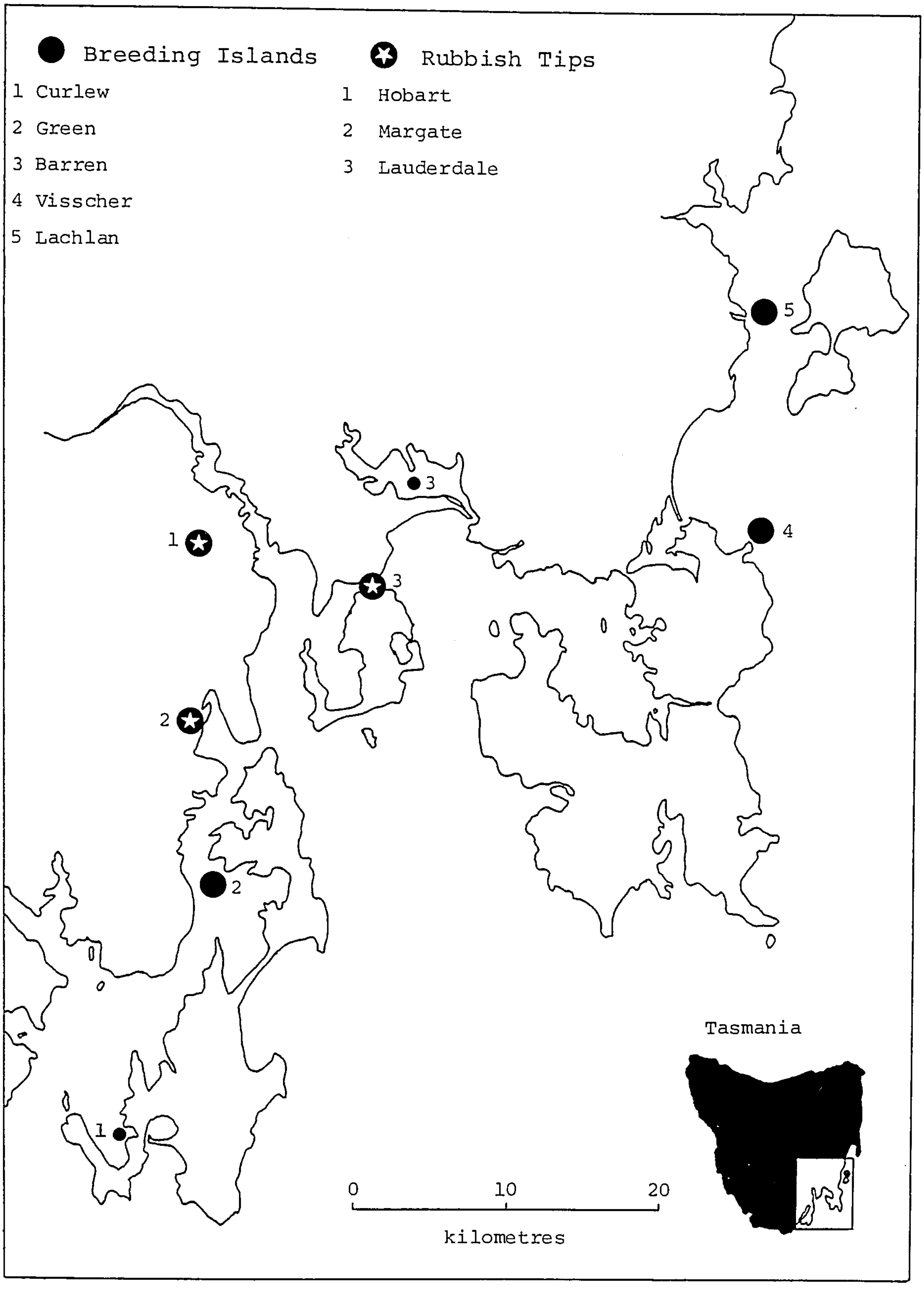


FIGURE 3.11

Location of Kelp Gull Breeding Islands and Large Rubbish Tips in South-East Tasmania



3.3.4 Behaviour

(a) Individual behaviour

Murphy (1936) suggested that the movements of the Kelp Gull depended on both latitude and the degree of isolation of the population. This generalization has been confirmed in parts of the species' distribution where banding studies have been conducted. Birds in the most southerly breeding population on the Antarctic Peninsula are migratory, although a few adults remain throughout winter in the vicinity of bases (Watson, 1975). Parmelee (pers. comm. 1981) reports recoveries of birds banded on the Antarctic Peninsula from Chile and Argentina. Watson (1975) states that populations on sub-antarctic islands are largely sedentary. This has been supported by studies on Macquarie Island where banding has been carried out for many years and no birds have been recovered elsewhere (Merilees, MS). By contrast, Brooke and Cooper (1979a) believed that some birds from Marion Island reached South Africa whereas the continental population appeared to be sedentary. There is little information available for South America although long distance movements can occur as Olrog (1974) reported a bird recovered 800 km from the banding place after 2½ years.

Most information on Kelp Gull movements is available from New Zealand where over 60 000 birds have been banded (Cossee *et al.*, 1981). None has been recovered outside New Zealand (Robertson, pers. comm. 1982). Fordham (1968) studied dispersal patterns of the population in the Wellington area and found that movements were restricted and randomly directed. The mean recovery distance for first year birds recovered away from their natal islands was 27 km and for older birds was 23 km. The furthest movement recorded by Fordham was about 480 km from the banding place. Movements up to 835 km have since been recorded in New Zealand (Robertson, 1973), but there has also been evidence of marked fidelity to an area as shown, for example, by one bird recovered at its banding place 13 years after banding (Robertson, 1974).

In Australia, Kelp Gulls have been banded since breeding was first recorded on Moon Island in New South Wales. Incredibly, the first recovery was of a first year bird collected eight months after banding near Fremantle, Western Australia, a straight line distance of 3347 km (Gray, 1967). This recovery supported the view of the New South Wales colony acting as the centre of dispersal for the Australian population (see Section 3.3.3). A second recovery was of a bird about six months old which had moved 23 km (Purchase, 1969). Battam (1970) found that young birds on Moon Island dispersed from the colony as soon as they were fledged and were not subsequently seen there.

Most banding of Australian Kelp Gulls has been carried out in Tasmania by the Shorebird Study Group of the Bird Observer's Association of Tasmania. The birds have been banded as "runners" (not yet fledged) on the three main breeding islands since the 1976/77 breeding season. Since 1977/78 each bird has been given a single colour band to designate the year of banding as well as the standard metal band. The relative positions of the two bands has been used to designate the natal island. Table 3.10 gives the numbers of birds banded during this program.

TABLE 3.10

Numbers of Kelp Gulls Banded over Five Seasons on Three Breeding Islands in South-east Tasmania by the Bird Observer's Association of Tasmania. Data Supplied by Harris (pers. comm. 1981)

Breeding season	Band colour	Number of birds banded on colonies		
		Green Island[a]	Visscher Island[b]	Lachlan Island[c]
1976/77	-	50	-	-
1977/78	orange	127	-	-
1978/79	black	182	-	-
1979/80	blue	182	9	-
1980/81	green	170	-	46

a. Colour band on left leg, metal band on right leg.

b. Colour band above metal band on right leg.

c. Colour band below metal band on right leg.

There have been 11 recoveries away from the banding sites and the longest distance covered was 37 km (Harris, pers. comm. 1981). The mean recovery distance for the four first year birds was 18.5 km and for older birds was 23.6 km. A t-test (two-tailed test, 9 d.f.) indicated that there was no significant difference between these means which were similar to Fordham's (1968) values for the Wellington population. The most extensive movement recorded by us was for a bird banded on Lachlan Island which had moved 87 km to Margate Tip (see Figure 3.11) six months after banding.

The habitat preferences of the Kelp Gull are similar to those of the Pacific Gull (see Section 3.2.4). Seabird watches from vessels travelling in various parts of the species range have shown that Kelp Gulls are generally found within about 10 km of land (Darby, 1970; Bartle, 1974; Summerhayes *et al.*, 1974; Zink, 1978; Duffy, 1981). Some exceptions have been reported which indicate that Kelp Gulls fly beyond coastal waters at times. Dunnett (1977a) recorded South African birds up to 46 km from shore, but pointed out that they tended to follow the ship. Similarly, Bartle (1974) noted that New Zealand birds followed inter-island ferries across Cook Strait. Norris (1965) made observations from a submarine and recorded Kelp Gulls offshore occasionally, always in fine weather and calm seas. In Australia, Barton (1978) collected an adult male Kelp Gull in company with Pomarine Skuas (*Stercorarius pomarinus*) 13 km offshore from Eden, New South Wales.

Kelp Gulls readily move inland in many parts of their range. Murphy (1936) stated that they occur far from salt water in South America, often in mountainous regions. An indication of the extent of their distribution is given by Olrog (1974) who reported a Kelp Gull 500 km inland in Argentina. Kelp Gulls show similar habitat preferences in New Zealand where they are widespread inland (Bull, 1971). There are a number of records of birds occurring at considerable altitudes in New Zealand (e.g. Stidolph, 1952, 1953; Caughley, 1958) up to at least 9000 feet (approx. 2750 m) (Child, 1975). In South Africa, Brooke and Cooper (1979b) have commented that the South African Kelp Gull differs from the South American and New Zealand populations in that it rarely feeds inland. They reported records of birds only as far as 14 km inland (at a rubbish tip), and suggested that Kelp Gulls may be excluded from exploiting terrestrial food sources more extensively by the generally low soil moisture content and possible competition from the grassland avifauna. Kelp Gulls have been reported to feed on terrestrial invertebrates on sub-antarctic islands: Burger (1978) rarely observed them foraging more than 200 m inland in his study area on Marion Island, but Bernstein (MS) invariably encountered birds on the central plateau of Macquarie Island.

In Australia, Gibson (pers. comm. 1981) has concluded that Kelp Gulls feed predominantly on the shoreline in New South Wales, and there are no reports of Kelp Gulls inland in Victoria, South Australia or Western Australia. Kelp Gulls are sighted mainly on the shoreline of south-east Tasmania. However, they regularly visit the Hobart rubbish tip 3.5 km inland (see Section 4.1), often flying over Ridgeway (Harris, pers. comm. 1981) which has an elevation of about 350 m, and probably following a flight line about 14 km overland (see Figure 4.1). Harris (pers. comm. 1981) has also reported sightings of Kelp Gulls flying over mountains heading inland from Margate (see Figure 3.11).

The Kelp Gull has an essentially diurnal rhythm of activity as does the Pacific Gull, although Watson (1975) noted that Kelp Gulls in the Antarctic and sub-antarctic are partly nocturnal in feeding patterns. Fordham (1963) described the roosting activity of New Zealand birds on an island also used for breeding. They arrived in the late afternoon and settled on the water 100-200 m offshore, then eventually flew to the island after dark although they sometimes remained on the water all night, particularly in stormy weather. Activity increased after first light and most gulls had left the island within two hours. Williams (1977) reported a similar pattern in a South African colony, except that the birds assembled on the island then flew to the water at dusk where they remained all night, then re-assembled on the island at first light prior to departure. By contrast, at another site in South Africa McLachlan *et al.* (1980) reported that Kelp Gulls roosted at night in groups along the drift line of beaches where they also began feeding at first light.

When not feeding during daylight hours, Kelp Gulls may congregate in open loafing areas such as *Salicornia* flats (Shaughnessy, 1980). The daytime roosts used in the Hobart area are analysed in Section 4.3.1.

Although it is primarily a scavenger of the intertidal zone (Brooke and Cooper, 1979b), the Kelp Gull is a very versatile feeder from a wide range of foraging techniques. It has been reported as kleptoparasitic upon the oystercatchers *Haemotopus ostralegus*, *H. chathamensis* (Baker, 1974) and *H. moquini* (Hockey, 1980), Cape Petrels, *Daption capense* (Edgar, 1975) and Cape Cormorants, *Phalacrocorax capensis* (Brooke and Cooper, 1979b). It has also been reported to take the eggs of nesting seabirds (e.g. Murphy, 1936; Taylor and Wodzicki, 1958; Robertson, 1964) and to kill both young (e.g. Gwynne and Gray, 1959) and adults (e.g. Williams, 1963; Cooper, 1977) of smaller bird species. Kelp Gulls may employ a "puddling" technique (see Section 3.1.3) to force shellfish up out of wet sand and also dig shellfish out of sand (Brunton, 1978). Like the Pacific Gulls, the Kelp Gull commonly uses the technique of prey-dropping to open shellfish (Bain, 1969; Siegfried, 1977; Brunton, 1978; McLachlan *et al.*, 1980). Other types of feeding behaviour sometimes used are plunge-diving for submerged prey (Berutti *et al.*, 1979; Bernstein, MS) and soaring in updraughts to catch flying insects (Summers, 1977).

(b) Social behaviour

The Kelp Gull has been described as gregarious (Watson, 1975) and often forms large flocks. Fordham (1968) concluded that feeding flocks in New Zealand are dynamic associations which usually form at the same sites each day. Members of these flocks do not necessarily originate from the same breeding colony or roosting site. Birds are often driven from flocks by others, and some birds move between flocks during the day while others visit the same site regularly. The age structure of the flocks varies through the year as adults and first year birds join the flocks early in the year and adults later begin to leave for the breeding colonies in spring. Fordham also found that some birds occurred singly or in pairs; Harris (1954) noted that Kelp Gulls in Otaga Harbour, New Zealand, defended feeding territories in pairs and the same behaviour has been recorded on the Antarctic Peninsula (Maxon and Bernstein, 1980). The patterns of association recorded in our study are given in Chapter 4.

Flocks of Kelp Gulls have been recorded mobbing larger birds which were potential predators or competitors: Cape Vulture, *Gyps coprotheres* (Boshoff, 1980), White Heron, *Egretta alba* (Edgar, 1973), Australian Harrier, *Circus approximans* (McKenzie, 1955; Fordham, 1963) and Kea, *Nestor notabilis* (Jackson, 1969). In some cases the victims were forced down into water and drowned by the gulls.

Fordham (1963) described a repertoire of nine distinct calls for the Kelp Gull, most being delivered in characteristic postures. These are summarized in Table 3.11.

Fordham (1963) also described a number of other postures without associated calls which are involved in courtship and behaviour: "facing-away", "upright", "forward", "hunched" and "grass-pulling". He concluded that there appeared to be no significant differences in behavioural repertoire between the Kelp Gull and the well-studied Herring and Lesser Black-backed Gulls.

TABLE 3.11

A Summary of the Vocal Repertoire of the Kelp Gull (after Fordham, 1963, 1964b)

Call	Sound	Description	Caller	Location	Context
Alarm	'kwe-ah'	loud, repeated, staccato call	second year to adults	on land, in air	disturbance of colony; disturbance at feeding sites*
Anxiety	'ha ha haha'	chattering call	breeding adults	mainly in air	disturbance close to nest
Charge	'oo-waaaaah'	piercing scream	adults, immatures*	in air, on land*	defence of nest against predator; charging another gull during feeding*
Call note	'gorah! gorah!'	hoarse call	second year to adults	on land	in relaxed posture
Long	'uh, uh, ee-ah-ha-ha-ha-ha-ha-ha'	complex call	second year to adults	on land, on water	defence, pair formation
Mew	'waaaaah'	wailing call	second year to adults	on land	courtship, nest-relief, calling to chicks
Choking	'wo-wo-wo-wo-wo'	rises and falls in pitch	second year to adults	on land	nest building, aggression
Food-begging	'kle-oo, kle-oo'	soft fluty cry	young and females	-	begging food from parent; begging food from mate, prior to copulation
Copulation	'cor-cor-cor' then 'car-car-car'	rapidly repeated, becoming harsher	males	on land	during copulation

* Additional observations made during this study

3.3.5 *Diet*

The wide geographic range of the Kelp Gull exposes them to an extensive range of potential prey items. This section reviews dietary information for Kelp Gulls in Australia and summarizes the literature on diet on other areas. Appendix 1 presents some dietary data for Kelp Gulls in Tasmania.

Like the Pacific Gull, the Kelp Gull is essentially a shoreline and surface feeder. Molluscs probably form the most significant item of the natural diet throughout its range. Bivalve molluscs are the basic food in New Zealand (Oliver, 1974) and South Africa (Brooke and Cooper, 1979b); in South Africa these appear to be mainly mussels (e.g. Hockey, 1980; McLachlan *et al.*, 1980; Shaughnessy, 1980). Similarly, Murphy (1936) considered that molluscs formed the bulk of the Kelp Gull's natural diet in South America. Molluscs, either limpets or mussels, have also been found to be the main component on some of the sub-antarctic islands (Falla, 1937; Merilees, MS) and Kelp Gulls on the Antarctic continent feed mainly on limpets (Watson, 1975; Bernstein, MS). Other molluscs which have been recorded in the diet of Kelp Gulls include the following groups: cephalopods (Fordham, 1970; Shaughnessy, 1980; Merilees, MS); chitons (Fordham, 1970; Merilees, MS) and terrestrial snails (Brooke and Cooper, 1979b).

Invertebrates other than molluscs have also been recorded: terrestrial invertebrates such as earthworms (Oliver, 1974; Burger, 1978; Merilees, MS) armyworms (Bell, 1960) and maggots (Harris, pers. comm. 1980), marine invertebrates such as crustaceans and echinoderms (Murphy, 1936; Fordham, 1970; Berruti *et al.*, 1979; Bernstein, 1979), and flying insects (Fordham, 1970; Summers; 1977; McLachlan *et al.*, 1980; Merilees, MS).

The natural vertebrate food of the Kelp Gull consists of live prey and carrion. The live prey is mainly small fish (Murphy, 1936; Oliver, 1974; McLachlan *et al.*, 1980; Bernstein, MS) and eggs, young and adults of other bird species (see Section 3.3.4) as well as the eggs and young of Kelp Gulls (Murphy, 1936; Fordham, 1964b; Burger and Gochfeld, 1981a). Other live prey items are small mammals (Fordham, 1964b, 1970; Bernstein, MS), reptiles (Oliver, 1974) and amphibians (Fordham, 1964b, 1970; Prévost and Mougin, 1970). Larger vertebrates (fish and marine mammals) are eaten when they occur as beach-washed carrion (Stead, 1932; Murphy, 1936; Oliver, 1974; Shaughnessy, 1980).

Plant materials also occur as a minor component of the natural diet. Some, such as berries and seeds (e.g. McLachlan *et al.*, 1980), are probably deliberately ingested whereas other plant material is probably taken incidentally as with inert material like pebbles (Bernstein, MS).

The Kelp Gull has also utilized a wide range of man-made food sources. In the past, whaling and sealing operations introduced an abundant source of food (Murphy, 1936; Oliver, 1974). Kelp Gulls have also been attracted to boats and feed on garbage or fishing offal thrown overboard (Stead, 1932; Murphy, 1936; Crockett, 1954; Oliver, 1974). The offal produced by land-based fish and meat processing works is a major source of food in some areas (e.g. Dawson, 1958; Fordham, 1964b, 1968, 1970; McLachlan *et al.*, 1980). In the Hobart area, Kelp Gulls have been noted feeding at an abattoir, which is now closed, at Sorell (Thomas, 1967; Wall, 1970) and another at Lutana (Thomas, 1976) which is discussed in Section 4.2. Agriculture has increased the food available to Kelp Gulls which feed on cleared land in New Zealand (Oliver, 1974) and South America (Murphy, 1936); they are reputed to kill lambs and weakened sheep in Patagonia and the Falkland Islands (Murphy, 1936) and in New Zealand (Stead, 1932; Dawson, 1958; Oliver, 1974), and to scavenge carcasses of domestic stock in these areas. Deer-culling operations in mountainous regions of New Zealand have also attracted Kelp Gulls to feed (Challies, 1966; Lambert, 1970; Reid, 1970).

Rubbish tips provide a supply of man-made wastes which are utilized by Kelp Gulls throughout the range of the species: South Africa (Manry, 1978; Brooke and Cooper, 1979b), South America (Murphy, 1936), Antarctica (Tomo, 1971; Parmelee *et al.*, 1977), sub-antarctic islands (Merilees, MS) and New Zealand (Fordham, 1964b, 1968, 1970; Muller, 1969). There are no records of Kelp Gulls feeding at tips in any Australian mainland states except Western Australia where they have been recorded at a tip at Esperance (Cooke, pers. comm. 1981). They are commonly found at tips in south-east Tasmania (Thomas, 1967, 1976; Fletcher *et al.*, 1980); their use of these tips is examined in Chapter 4.

3.3.6 Reproduction

The Kelp Gull generally nests in colonies although isolated pairs may nest on rock stacks (Shaughnessy and Shaughnessy, 1976; Falla *et al.*, 1979). A study of two mainland and four island colonies in South Africa by Burger and Gochfeld (1981a,b) indicated that the colonies were situated in a variety of habitats ranging from rocky cliffs to a sandy island in a salt lake, although all colony sites differed from the surrounding areas and were generally inaccessible to terrestrial predators. Selection of individual nest sites appeared to be based on slope and cover: pairs nested on the most level site available within their territory and nested next to rocks or vegetation where available. Fordham's (1964a) study of one New Zealand island colony revealed a similarly wide range of habitat used for nest sites, but with a high proportion (67%) of nests without any cover. Many of these were situated in pasture. Although Kelp Gulls breed mainly along the coast of New Zealand, colonies are also found near permanent water in mountainous regions (Oliver, 1953; Caughley, 1966). A similar pattern occurs in the southern portion of South America (Murphy, 1936). Some instances of rooftop nesting have also been recorded in New Zealand (Turbott, 1969). All the Australian colonies are on islands, and in the case of the three large Tasmanian colonies, the island is shared with a colony of Pacific Gulls.

Nests are generally situated close to each other. The mean nearest neighbour distances for nests on each of the six South African colonies surveyed by Burger and Gochfeld (1981a) ranged from 2.5 m to 9.7 m. They re-calculated data given by Fordham (1964a) for a large New Zealand colony and obtained mean nearest neighbour distances ranging from 2.1 m in the area of high nesting density to 6.1 m in the low density area. A second New Zealand colony had mean distances of 3.1 m and 3.8 m in two areas. A survey of Green Island, the largest colony in Australia, revealed a mean nearest neighbour distance of 2.9 m (Coulson *et al.*, in prep.).

Nests are constructed from available plant materials, particularly moss, grass, seaweed and sticks, as well as feathers (Murphy, 1936; Fordham, 1964b; Oliver, 1974). Wool is included in the structure in the Falkland Islands (Murphy, 1936). Beruldsen (1980) states that Kelp Gulls' nests are indistinguishable from those of Pacific Gulls, but Kelp Gull nests are generally a far more substantial structure, often with a "volcano" appearance (Harris, pers. comm. 1981). Fordham (1964a) gives the following mean dimensions: diameter of complete nest 44.5 cm, diameter of bowl 22.9 cm, depth 12.7 cm (c.f. Section 3.2.6).

Because of the wide latitudinal range of the Kelp Gull, the breeding season is variable in timing and length. Murphy (1936) reported that the breeding season on the Lobos Islands (off northern Peru) was continuous throughout the year; by contrast, egg laying is restricted to the period from early November to early December in the Antarctic and sub-antarctic (Watson, 1975). Fordham (1964a) found that the first eggs were laid on 18th October and the entire laying period continued for 99 days in a New Zealand colony which has a similar latitude to the breeding colonies in Australia. On Green Island near Hobart, egg laying commenced on 24th October $\pm$ 7 days (Coulson *et al.*, in prep).

Mean clutch size for the New Zealand colony was 2.3 eggs; 48% of complete clutches had three eggs, 42% had two and 9% had a single egg (Fordham, 1964a).

TABLE 3.12

A Comparison of Egg Measurements for Kelp Gulls in New Zealand and Australia. New Zealand Data from Fordham (1964a); Australian Data from Coulson *et al.* (in prep.)

Measurement	Location	Sample Size	Mean	Range
length (mm)	New Zealand	798	69.2	59.7 - 82.9
	Australia	200	70.0	61.6 - 77.5
width (mm)	New Zealand	798	47.0	41.0 - 51.5
	Australia	200	48.0	41.9 - 53.7
weight (g)	New Zealand	787	80.1	57 - 105
	Australia	45	88.7	79.5 - 101.5

The dimensions and weight of Kelp Gull eggs are similar in New Zealand and Australia, as shown in Table 3.12. Fordham (1964a) found that the most common ground colours of the shell were grey, grey-green and green, and most eggs had brown superficial markings of varied size and shape. Dawson and Braithwaite (1963) suggested that "scribble" markings occurred only on the third egg of a clutch.

Fordham (1964b) studied incubation and development of chicks in New Zealand. He found that both sexes incubated the eggs, and the incubation period was 27 days (range 23-30). Orrego and Campusano (1971) recorded nest temperatures ranging from -1.5°C to 29°C on South Shetland. The chicks are brooded and fed by both parents for three or four days after which the chicks leave the nest for increasingly long intervals; after five or six days they also take to the water readily when alarmed (Fordham, 1964b). Chicks are capable of independent thermoregulation by 15 days (Orrego *et al.*, 1975). They grow steadily: chicks in New Zealand gained approximately 100 g per week (Fordham, 1964b) and the growth rate of chicks in the short sub-antarctic season is higher (Despin *et al.*, 1972). The young are fledged after seven weeks in New Zealand (Fordham, 1964b).

3.3.7 Population

(a) Natality and mortality

The spread of ages at which Kelp Gulls are recruited into breeding populations is not known with any certainty, but Fordham (1970) considered that some birds may breed in their third year and most begin to breed in their fourth year in New Zealand.

Mean hatching success for nine New Zealand colonies was 68% and mean nest success was 1.4 young presumed fledged per pair. The majority of unsuccessful eggs simply failed to hatch, but eggs were also lost through flooding of lakes and rivers, high tides, collapse or desertion of nests, predation by mammals (including man) and cannibalism by neighbouring pairs (Fordham, 1964b, 1970). Carroll (1968) found that Harriers *Circus approximans* regularly took eggs from unsupervised Kelp Gull nests. Burger and Gochfeld (1981a) recorded high levels of egg cannibalism in some South African colonies which had apparently been subject to regular human disturbance.

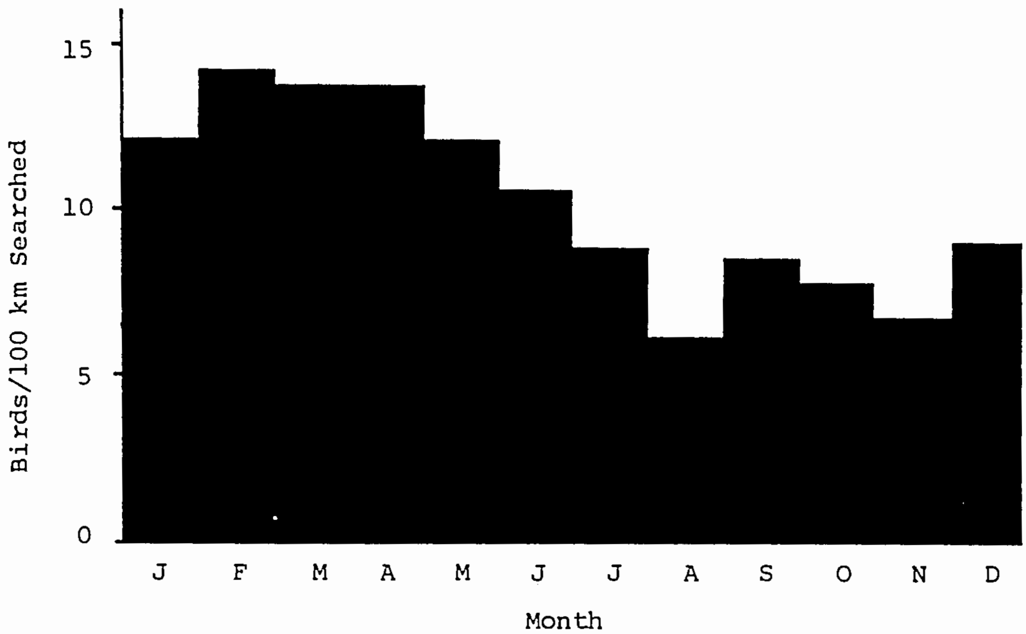
Fordham (1970) also determined the causes and rates of mortality for Kelp Gulls in New Zealand. Attack by adults was the major mortality factor (75%) before fledging; only 3% were preyed on by mammals (stoats, *Mustela erminea*) and 22% died of unknown causes. Post-fledging mortality was also due largely (77%) to attacks by adults. In the first year after fledging, 70% of mortality occurred in the first two months and 92% in the first six months. The estimated survival rates were: first year, 0.79; second year, 0.89; and adult, 0.93.

Mortality of New Zealand Kelp Gulls follows a seasonal pattern. Figure 3.12 shows the monthly frequency of a total of 3627 birds found by beach patrols of the New Zealand coast over a 16 year period. Mortality was highest in summer and autumn and lowest at the end of winter. Van Tet's (1968) analysis of band recoveries in New Zealand showed a similar pattern, but did not detect elevated mortality in early summer. Some causes of mortality have been documented: predators (Norris, 1968), disease (Williams, 1955), shooting

(Fordham, 1970), a toxic "red tide" (Avery, 1979) and taking bait on fishing lines (Cunningham, 1952).

FIGURE 3.12

Monthly Frequency of Dead Kelp Gulls Located by Beach Patrols in New Zealand from 1964 to 1979. Compiled from Imber and Boeson (1969), Imber and Crockett (1970), Imber (1971), Roberts (1975), Crockett (1977) and Veitch (1975, 1976, 1977, 1978, 1979, 1980a,b, 1981)



The longevity of the Kelp Gull is not known with any certainty. In New Zealand, the premature loss of bands has not permitted realistic estimates of longevity (Fordham, 1967a). Merilees (1969) reported a bird at Macquarie Island which had attained a minimum age of approximately 14 years; the longevity record for Kelp Gulls in Australia is seven years four months (Leishman, 1981) but there have been relatively few birds banded.

(b) Population size

There are numerous reports of local concentrations of Kelp Gulls, particularly in New Zealand where thousands of birds may be recorded in flocks (e.g. Sibson, 1961). More meaningful surveys are taken over long periods of time or larger areas to yield density estimates usually expressed per unit length of coastline. Table 3.13 summarizes density values reported for a number of localities.

TABLE 3.13

Population Densities Reported for Kelp Gulls along some Coastlines of New Zealand and South Africa

Reference	Locality	Length of Coast (km)	Period of Survey	Density Range (gulls/km)
Wodzicki (1962)	Otaki Beach, N.Z.	11	March	12 - 42*
Brunton (1978)	Dargaville Beach, N.Z.	23	1 year	5 - 22*
McLachlan *et al.* (1980)	Eastern Cape, Sth. Africa	70	1 year	5 - 11*
Fordham (1968)	Coast east of Wellington, N.Z.	119	June	0.3 - 7
Fordham (1968)	Wellington area, N.Z.	241	April	2 - 68
Fordham (1968)	Wellington Harbour, N.Z.	53	4 years	22 - 127

* means of numerous counts.

The number of breeding pairs of Kelp Gulls in each Australian state is examined in Section 3.3.8. The total number of pairs in Australia is approximately 400, which is indicative of quite a small population when compared with Fordham's (1968) estimate of 5700 pairs in only the Wellington area of New Zealand.

The Bird Observers Association of Tasmania has attempted to estimate the absolute abundance of Kelp Gulls in south-eastern Tasmania (see Section 3.2.7). As shown in Table 3.14, the minimum population estimate in 1981 was 1040 and there was a 25% increase over the estimates for 1980 in areas which were surveyed in both years; a goodness-of-fit Chi-square test indicated that the difference was significant ($p < 0.001$, 1 d.f.).

TABLE 3.14

Minimum Population Size for the Kelp Gull in South-eastern Tasmania, from the Bird Observers Association of Tasmania June Census of Large Gulls

Year	Count for areas searched in both years	Count for all areas
1980	805	833
1981	1004	1040

3.3.8 Status

Murphy (1936) reported the Kelp Gull to be common around the coast of South America but did not discuss possible changes in status. In South Africa the species is also common and the population appears to be stable (Cooper,pers. comm., 1981). However, Kelp Gulls have attained pest status there: Randall and Randall (1980) reported that the gulls stole eggs from the only colony of Roseate Terns, *Sterna dougalli* in South Africa, and they have been reported to kill endangered Cape Vultures *Gyps coprotheres* (Boshoff, 1980). In New Zealand the Kelp Gull population has expanded markedly (Fordham, 1967b). Kelp Gulls are regarded as pests for reasons ranging from minor nuisances, such as the theft of golf balls (Jukes, 1978) to their reputation as sheep killers (Heather, 1966) and their serious impact on colonies of other species, and are not protected (Bell, pers. comm. 1981). They have also been poisoned near an airfield to reduce the incidence of aircraft strikes (Caithness, 1968).

Kelp Gulls are common on most sub-antarctic islands (Murphy, 1936). There is little information on possible changes in status: Williams *et al.* (1975) recorded an increase in numbers on Marion Island, but Copson (pers. comm. 1981) considers the population on Macquarie Island to be stable. Johnstone and Murray (1972) tentatively suggested that an increased number of sightings of Kelp Gulls in Antarctica may indicate an expansion of range in the south; Johnstone (pers. comm. 1981) now believes that the effect was due to an increased number of observers in the Antarctic and new locality records continue to be made (e.g. Sagar, 1976).

In Australia the Kelp Gull has been reported once in the Northern Territory (see Section 3.3.3) and is regarded as a "vagrant" in Queensland (Roberts, 1979). The number of breeding pairs in New South Wales was estimated as 12-15 pairs in 1979 and Lane (1979) noted that the growth in breeding population had been slow but steady, with nesting extending to other islets in the Five Islands Group. Morris (1979) warned that there was potential for predation on Little Terns, *Sterna albifrons*, which are declining in numbers in New South Wales, if the Kelp Gull population increases significantly.

Wheeler (1967) classified the Kelp Gull as "rare" in Victoria. The sole Victorian breeding colony has slowly increased in size to three pairs in the 1980/81 season (Warneke, pers. comm. 1981). Close (1981) considered the Kelp Gull to be "very uncommon" in South Australia. Its status in Western Australia is unclear: Serventy and Whittell (1976) mention very few records, but Cooke (pers. comm. 1981) reports that a small population exists in the Esperance region and suspects that it may breed there.

Tasmania is the stronghold of the Kelp Gull in Australia. The Tasmanian population has increased far more rapidly than in other states. In 1972, a "large" flock of at least 40 near Hobart was worthy of note (Thomas, 1973), but in 1981 we recorded flocks of over 400 (see Section 4.1). The population has also expanded from its nucleus in the Hobart area to the east coast of the state (Thomas, 1976), but the majority of birds are still found in south-east Tasmania (Fletcher *et al*., 1980).

The largest breeding colony on Green Island has increased from about 120-125 pairs in the 1976/77 season (Thomas, 1976; Green, 1977) to 275 pairs in 1981/82 (Coulson *et al*., in prep.). The two other major colonies are on Lachlan Island and Visscher Island which had 60 and 40 pairs, respectively, in 1981/82 (Harris, pers. comm. 1982).

The main concern about the Kelp Gull's rapid population growth is the possibility of competition with the Pacific Gull on breeding islands. Fletcher *et al*. (1980) reported considerable interaction between the two species in the breeding colonies and suggested that the population of Pacific Gulls may decline in consequence. This problem is discussed in Chapter 5.

4
Behaviour of Gulls in Tasmania

4. BEHAVIOUR OF GULLS IN TASMANIA

This chapter presents the findings of our field work, which was aimed at investigating the factors influencing the use of feeding sites by Pacific and Kelp Gulls, the way in which each species exploited these sites, and the nature of interactions between the species. The relationship between the number of gulls using a tip and various factors descriptive of the tip, such as tip size, was examined by surveying 28 rubbish tips in Tasmania. Detailed regular surveys were also made at selected feeding sites to investigate usage of the sites by gulls, changes over time and the effect of various environmental variables. In addition, behavioural observations were made to examine the feeding and agonistic behaviour of the gulls.

4.1 Distribution of Gulls at Rubbish Tips

We surveyed all rubbish tips near the coast in south-east Tasmania, from Triabunna south to Huonville but excluding Bruny Island, at least once during winter. Regular visits were made to the three large tips, referred to in this study as Hobart, Lauderdale and Margate, throughout June, July, August and September of 1981 (see Section 4.2). In addition, tips in Launceston and in towns along the north-west coast of Tasmania were surveyed at least once during the same period. The locations of all tips surveyed during the study are shown in Figures 4.1 and 4.2.

4.1.1 General survey method

As well as counting the number of Kelp and Pacific Gulls present at each tip, parameters relating to the disposal method, location and size of each tip were recorded as possible factors influencing the usage of tips by gulls. The presence of any other birds was also noted.

(a) Counting. An instantaneous count was made of all birds present on each tip visit and was recorded on a standard data sheet. The count included all birds within the tip boundary, or in the immediate vicinity of the tip if there was no definite boundary. With the aid of 10 x 50 binoculars, all large gulls were counted and individually scrutinised to determine species, age class and the presence of any leg bands. The two species were distinguished using the criteria listed in Section 3.3.2. Bill profile was the main criterion used, supplemented by other

FIGURE 4.1

Location of Rubbish Tips Surveyed in South-East Tasmania

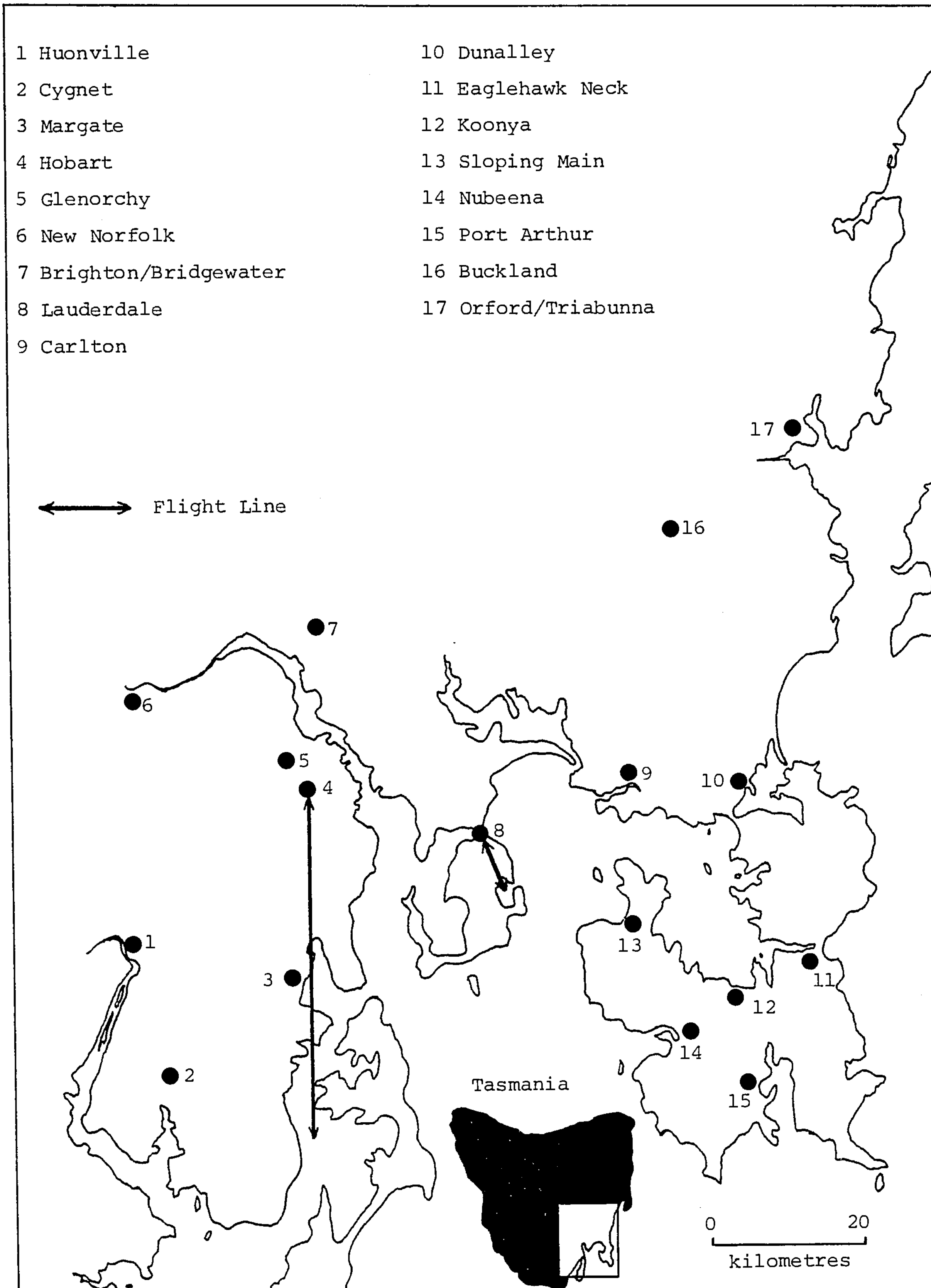
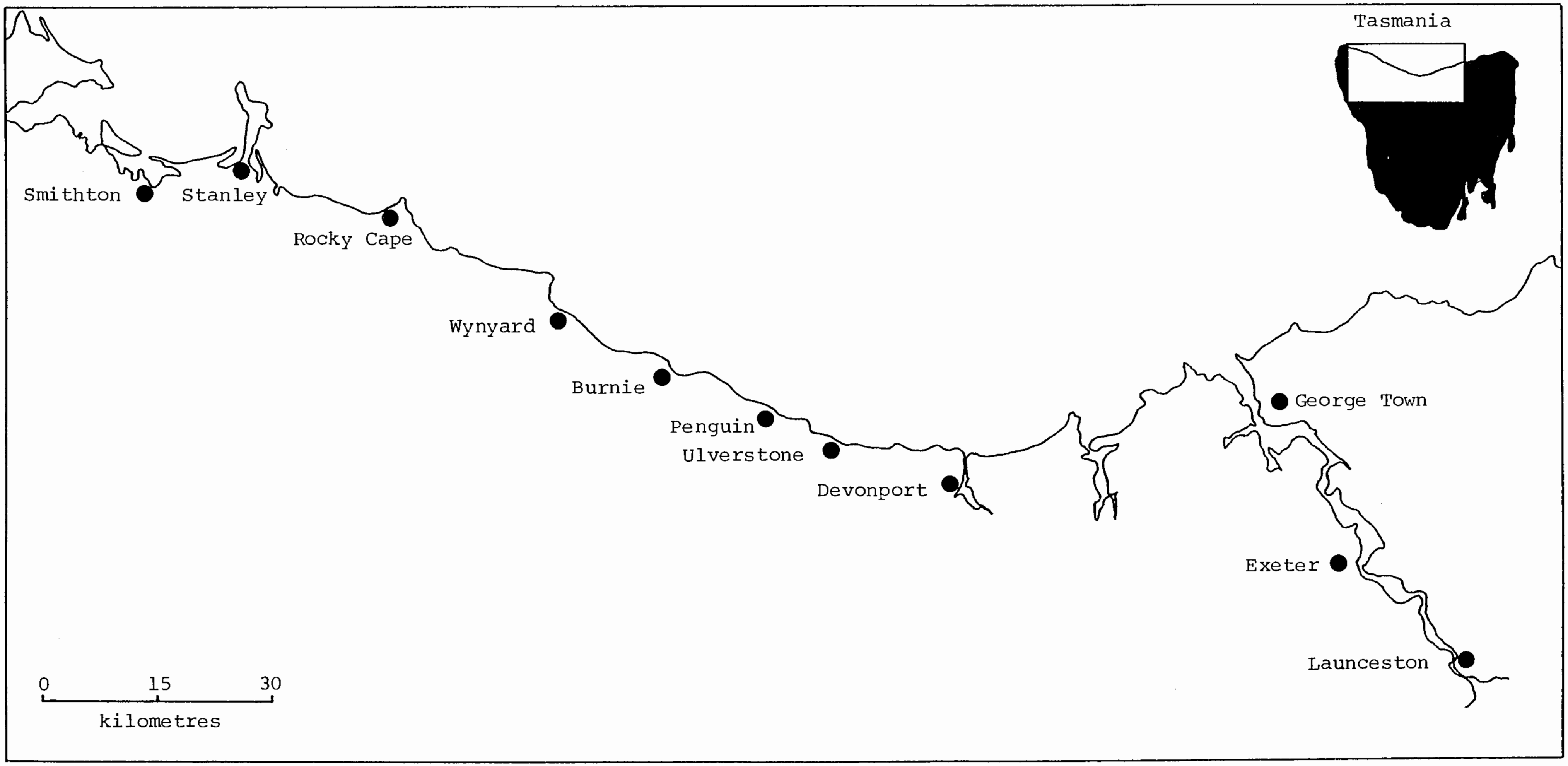


FIGURE 4.2

Location of Rubbish Tips Surveyed in Northern Tasmania



characteristics when the bill was obscured. The size of large flocks of other species, particularly of Silver Gulls, was estimated by counting in groups of approximately ten.

(b) Disposal method. The method of garbage disposal employed at each location could affect the availability of garbage to gulls, and has been classified as sanitary landfill, trench or surface spreading, according to the categories used by the Tasmanian Department of the Environment which licenses the operation of waste disposal sites in this state. These disposal methods and the administration of waste disposal in Tasmania are discussed in Section 5.2.

(c) Distance from water. The shortest distance between each tip and natural gull foraging habitat along the water's edge was included because of its possible effect on the readiness of gulls to fly to the tip. The direct distance of each tip from the sea or river estuary as appropriate has been estimated to the nearest 0.1 km using 1:150 000 scale maps produced by the Tasmanian Lands Department, and the known locations of the tips, which were supplied by the Tasmanian Department of the Environment.

(d) Size. The amount of food reliably available to gulls could be expected to influence the numbers of gulls found at particular tips. Two parameters considered to be likely indicators of the amount of garbage deposited in each tip are the human population served by each tip and the annual volume of garbage for which the Department of the Environment licence had been granted.

Estimates of the population served by the four large south-east tips were provided by the relevant city and municipal councils. Figures for the small south-east tips and for the tips in northern Tasmania were estimated to the nearest 250 using 1976 census data and other information provided by the Australian Bureau of Statistics. Licence volumes were determined from records supplied by the Department of the Environment.

4.1.2 General survey results

(a) Bird species present. The bird species most consistently present at tips during surveys were the Kelp Gull, Pacific Gull, Silver Gull, Forest Raven (*Corvus tasmanicus*), Common Starling (*Sturnus vulgaris*), and the House Sparrow (*Passer domesticus*). The maximum number of these species seen at any one time at each tip is shown in Table 4.1.

TABLE 4.1

Location, Disposal Method and Licensed Volume for each Tip Surveyed and Maximum Numbers of Birds Present, June-August, 1981. Key to disposal methods: S.L. = Sanitary Landfill; T = Trench; S.S. = Surface Spreading

Location	Disposal Method	Distance from Water (km)	Population Served	Licensed Volume (tonnes per year)	Number of Visits	Maximum Number of Birds Present					
						Kelp Gull	Pacific Gull	Silver Gull	Forest Raven	Common Starling	House Sparrow
Large south-east tips:											
Glenorchy	S.L.	3.3	45 000	25 000	3	0	0	1	2	50	20
Hobart	S.L.	3.5	55 000	80 000	40	443	11	1 730	128	300	40
Lauderdale	S.L.	0.2	46 000	1 500	19	399	92	2 200	138	105	30
Margate	S.L.	0.5	18 000	20 000	20	229	20	675	22	5	30
Small south-east tips:											
Brighton/ Bridgewater	T	3.6	3 500	1 000	1	0	0	0	0	0	50
Buckland	S.S.	14.3	250	100	1	0	0	0	0	0	0
Carlton	T	1.0	250	500	3	1	0	80	0	0	0
Cygnet	S.S.	3.0	750	500	1	0	0	40	2	0	0
Dunalley	S.S.	1.0	250	100	1	0	0	2	4	0	0
Eaglehawk Neck	S.S.	1.0	250	500	1	0	0	0	0	0	0
Huonville	S.S.	0	1 250	500	1	0	0	110	0	40	20
Koonya	T	0.8	250	500	2	0	0	2	0	0	0
New Norfolk	S.S.	1.5	6 750	1 200	1	0	0	0	0	0	20
Nubeena	S.S.	1.5	250	500	1	0	0	0	0	0	0

Continued ...

TABLE 4.1 (Continued ...)

Location	Disposal Method	Distance from Water (km)	Population Served	Licensed Volume (tonnes per year)	Number of Visits	Maximum Number of Birds Present					
						Kelp Gull	Pacific Gull	Silver Gull	Forest Raven	Common Starling	House Sparrow
Orford/ Triabunna	S.S.	0.8	1 250	400	2	14	0	50	3	0	0
Port Arthur	S.S.	0.8	250	500	1	0	0	0	0	4	0
Sloping Main	T	1.5	250	100	1	0	0	0	0	0	0
Northern tips:											
Burnie	S.L.	1.6	19 250	32 000	1	0	45	820	40	20	0
Devonport	S.L.	0.1	19 500	10 000	1	0	7	1 100	38	20	0
Exeter	T	2.0	500	2 000	1	0	0	10	0	50	10
Georgetown	S.L.	2.2	5 500	2 000	1	0	0	0	0	0	1
Launceston	S.L.	1.0	63 500	60 000	6	0	341	2 380	150	56	100
Penguin	S.S.	3.0	2 500	1 000	1	0	0	0	0	1	30
Rocky Cape	S.S.	0.7	250	250	1	0	0	0	0	0	0
Smithton	S.L.	0	3 250	2 000	1	0	92	250	31	5	5
Stanley	T	0.4	750	250	1	0	0	0	0	0	10
Ulverstone	S.L.	0.1	9 000	3 500	1	0	27	250	2	0	10
Wynyard	S.L.	0.2	4 500	8 000	1	0	0	80	1	0	7

Other species recorded on at least one tip survey are listed in Table 4.2. Flocks of about 10 Feral Pigeons (*Columba livia*) were regularly seen at Hobart and Margate tips, but no pigeons were seen at other tips. About 30 Purple Swamphens (*Porphyrio porphyrio*) were seen during each survey of the Launceston tip. The presence of the gulls, Forest Raven, Common Starling, House Sparrow and Feral Pigeon at tips is in accord with the acknowledged scavenging and opportunistic habits of those species. The occurrence of the other species listed in Table 4.2 appeared to be related to the habitat surrounding the tip rather than to the garbage itself. In general, these species were not observed feeding on the rubbish but utilising other resources available at the tips; for example, the White-faced Herons recorded at Margate tip were wading in shallow ponds beside the workings of the tip, and the swampy areas within the Launceston tip supported Tasmanian Native Hens and Purple Swamphens. Most of the tips were closely bordered by open forest, and birds typical of that vegetation type were recorded when they came within the boundaries of the tip. Some birds did utilise the tip as a food source: Purple Swamphens fed on refuse at Launceston tip and a Yellow-throated Honeyeater was recorded feeding on blossom among garden trimmings at Hobart tip.

TABLE 4.2

Bird Species Occasionally Recorded at Rubbish Tips in Tasmania

Species	Common Name	Location of Tip
Ardea novaehollandiae	White-faced Heron	Margate
Gallinula mortierii	Tasmanian Native Hen	Launceston
Porphyrio porphyrio	Purple Swamphen	Launceston
Vanellus miles	Masked Lapwing	Hobart, Launceston, Margate, Smithton
Columba livia	Feral Pigeon	Hobart, Margate
Cacatua roseicapilla	Galah	Lauderdale
Platycercus caledonicus	Green Rosella	Dunalley
Hirundo neoxena	Welcome Swallow	Hobart
Colluricincla harmonica	Grey Strike-thrush	Koonya, Penguin
Rhipidura fuliginosa	Grey Fantail	Exeter
Malurus cyaneus	Superb Fairy-wren	Margate, Penguin, Stanley
Lichenostomus flavicollis	Yellow-throated Honeyeater	Hobart
Zosterops lateralis	Silvereye	Penguin

No Kelp Gulls were observed at tips in Northern Tasmania, which is in keeping with the known distribution of the species. Pacific Gulls were more likely to be found at tips in northern Tasmania than in the south-east of the state. In south-east Tasmania, Pacific Gulls were seen only at three large tips in the Hobart area, while Kelp Gulls were seen at these tips and additionally at two smaller tips. The relationship between the numbers of Kelp and Pacific Gulls and the various tip parameters is examined below.

(b) Tip parameters. Factors relating directly to the tips (disposal method, distance from water, population served and licensed volume) are listed in Table 4.1, which also shows the number of surveys made at each tip.

The three numerical parameters were intercorrelated and correlated with the maximum number of Kelp and Pacific Gulls present at all tips surveyed in south-east Tasmania, and with the maximum number of Pacific Gulls counted at tips in the north of the state. The resulting correlation matrices are presented in Tables 4.3 and 4.4.

TABLE 4.3

Coefficients of Correlation between Tip Parameters and Numbers of Kelp and Pacific Gulls Recorded at Rubbish Tips in South-East Tasmania

	Population Served	Licence Volume	Number of Kelp Gulls	Number of Pacific Gulls
Distance from water	-0.03	-0.07	-0.10	-0.18
Population served		0.76*	0.81* 0.98***	0.58** 0.68***
Licence volume			0.69*	0.08
Number of Kelp Gulls				0.73*

* $p < 0.01$, N=17; ** $0.01 < p < 0.02$, N=17

*** $p < 0.01$, N=16 (excluding Glenorchy)

(i) South-east Tasmania tips. Table 4.3 shows that there was no significant correlation between the distance of the tip from water and the number of Kelp or Pacific Gulls, or with either of the other tip parameters. This finding suggests that neither species was inhibited by the distances from water required to reach the tips we surveyed, but does not show whether there is a maximum distance overland beyond which the gulls are unlikely to fly to reach food at tips. All of the tips surveyed were situated relatively close to the sea or the Derwent River estuary. Only one, small tip was more than 3.6 km from the water. This does not represent an unacceptable distance for Kelp Gulls at least, as shown by the large numbers which regularly flew 3.5 km to the Hobart tip. Also, Kelp Gulls occur far inland in New Zealand and South America (see Section 3.3.4).

Spaans (1971) observed Herring Gulls feeding at tips in the Netherlands up to 70 km from the coast. He found that, of tips serving municipalities of less than 10 000 people, those in coastal provinces were significantly more likely to have gulls present than were tips further inland. However, it was not clear from the study whether this difference was due solely to the increased distance from the coast, since there was also a difference in landscape between the study areas. The amount of food available may also influence the distance which gulls will fly to a tip. Spaans found a significant positive correlation between the number of inhabitants of a municipality and the number of Herring Gulls at its tip, and furthermore that distance from the coast was not a significant factor with tips serving more than 10 000 people. There are no large inland tips in south-east Tasmania to test this possibility with Kelp and Pacific Gulls.

It is possible that Pacific Gulls are more sensitive to distance from water than are Kelp Gulls. Pacific Gulls in Tasmania and in other parts of their range are rarely seen away from the coast (see Section 3.2.4). In south-east Tasmania, Pacific Gulls were seen at only three large tips (Table 4.1). Numbers were highest at Lauderdale tip, which is the closest of the three tips to the water, and lowest at Hobart tip which is the furthest from the water, with Margate tip intermediate in both numbers of Pacific Gulls and distance inland. Kelp Gull numbers at the same three tips reflected the size of the tip rather than the distance from water.

A surprising feature of the survey was the total absence of both Kelp and Pacific Gulls from the Glenorchy Tip and the sighting of only a single Silver Gull. Although the tip is situated further up the Derwent Estuary than the other large south-east Tasmanian tips, considerable numbers of Kelp, Pacific and Silver Gulls were recorded along the Derwent in the reaches level with Glenorchy (see Section 4.2) and would have been expected to use the food resource provided by the large Glenorchy tip. We learnt that gulls were actively discouraged by the tip management (see Section 5.1.2).

The two measures of tip size, population served and licence volume, were significantly correlated. This finding is not surprising, since a relatively large population would generate a correspondingly large volume of refuse, which would have to be dealt with by the tip serving that population. Both parameters were highly correlated with the number of Kelp Gulls present, but only population served was significantly correlated with the number of Pacific Gulls. The coefficient of correlation between population served and number of gulls present was considerably higher for both species when Glenorchy tip was excluded from the analysis (Table 4.3). There was no significant correlation between licence volume and Pacific Gull numbers, and the number of Kelp Gulls was more highly correlated with population served than with licence volume, although both of these correlations were significant. Of the two measures of tip size, population served appears to provide a better indicator of the number of large gulls feeding at the tip. The population figure is probably a more reliable index of the relative amount of refuse placed in tips than is the licence volume, and is also likely to reflect more accurately the amount of edible garbage available to gulls, since the licensed volume includes estimates of inedible industrial wastes. Both parameters have inherent limitations, and these are discused below.

Census data, the basis for the population figures used in this study, were collected in June and so provide winter population data. This is appropriate since this project was concerned with the significance of tips as a food resource during winter. The population of some areas, such as Carlton, would be swelled considerably during the summer holiday season, with a corresponding increase in the volume of rubbish deposited in the local tip.

There are two limitations of the population figures. One is that some demographic changes would have occurred since 1976 when the census information was collected. The other problem is the difficulty in estimating the number of people actually using a particular tip. In some cases the census area did not correspond well with the likely catchment area of a tip. Also, many residents in rural areas are likely to dump on their own land rather than travel to municipal rubbish tips. Nevertheless, the population figures in Table 4.1 would constitute a fair indication of the relative number of people using each tip.

The annual volume stated on the licence issued by the Department of the Environment is an arbitrary figure. In most cases these figures are probably a reasonable estimate of the volume actually dumped in each tip, but the figure for Lauderdale is certainly far below the actual volume, and will be reviewed when the licence is renewed (Burke, pers. comm., 1981). This is an important discrepancy, because Lauderdale is one of the three tips frequented by both Kelp and Pacific Gulls. Since Pacific Gulls were most numerous at the Lauderdale tip, the artificially low licence volume figure for that tip was probably at least partly responsible for the lack of a significant correlation between Pacific Gull numbers and licence volume in south-east Tasmania.

Numbers of Kelp and Pacific Gulls recorded at tips in south-east Tasmania were positively correlated, suggesting that both species are attracted by largely the same kind of rubbish tip or to each other.

No statistical analysis was carried out involving the type of disposal method employed at the tips. However, the method of disposal is indirectly related to the number of gulls present. Since the number of gulls is positively related to the population served by a tip, gulls are more likely to be found at tips where the sanitary landfill method is used because this is the method demanded by the Department of the Environment when large volumes of rubbish are involved. The various disposal methods are described in Section 5.2.

(b) Northern Tasmania. The correlation matrix for data from tips in northern Tasmania is presented as Table 4.4, and shows a very similar pattern to that for Kelp Gulls at tips in south-east Tasmania (Table 4.3).

TABLE 4.4

Coefficients of Correlation between Tip Parameters and Number of Pacific Gulls Recorded at Rubbish Tips in Northern Tasmania

	Population Served	Licence Volume	Number of Pacific Gulls
Distance from water	-0.07	0.01	-0.10
Population served		0.95*	0.91*
Licence volume			0.87*

* $p < 0.01$, $N = 11$

There was no significant correlation between the distance from water and any other parameter. However, the furthest inland of the surveyed northern Tasmanian tips was only 3 km from the sea, so the lack of a significant finding is as inconclusive as it was at the tips in south-east Tasmania.

Both population served and licence volume were found to be significantly correlated with the number of Pacific Gulls present. The coefficient of correlation between population served by the northern tips and their licence volume was higher than the corresponding figure for the south-eastern tips, suggesting that the licence volume estimates for the northern tips were more realistic.

4.2 Detailed Surveys of Large Tips and Shoreline Sites in South-East Tasmania

Regular counts of all gulls were made at three large tips in south-east Tasmania; Hobart tip, operated by the City of Hobart, Lauderdale tip, operated by the Municipality of Clarence, and Margate tip run by the Municipality of Kingston. In this section, the aspects of these three tips which appeared to be important to the gulls are described, and the numbers and age classes of gulls present at the tips are analyzed. In addition, we conducted regular counts of large gulls at a series of shoreline sites to obtain comparative information on their use of more natural feeding conditions in south-east Tasmania. The sites were selected to sample a variety of potential gull habitats in the general vicinity of the rubbish tips.

4.2.1 Description of the study sites

(a) Rubbish tips. All three tips used the sanitary landfill method of waste disposal which is described in Section 5.2. The appearance of the tips altered during the study period due to progressive filling of the sites by rubbish. However, the overall layout of each tip did not change drastically, and the descriptions given in this section represent the general conditions applicable for the duration of the study period.

Vehicles visiting the tips and bulldozer activity at the tips both had an effect on the behaviour of the gulls, as described in Section 4.3.1. The average frequency of vehicle use for each tip was determined by counting the number of vehicles entering the tips during timed intervals, and is presented in Table 4.5. Bulldozers were used intermittently to push dumped rubbish over the tip face and to cover rubbish with soil. We timed bulldozer operation during our visits, and the proportion of time during which the bulldozers were in use is also given in Table 4.5.

The order of frequencies with which vehicles used the different tips mirrors the order of size of the tips as measured by the population served. The higher proportion of time during which the bulldozer operated at Margate as compared with Hobart and Lauderdale tips is probably due to the different layout of the tips, which is described below.

TABLE 4.5

Average Vehicle Frequency and Proportion of Time when Bulldozers in Operation at Three Large Tips in South-East Tasmania

Tip	Vehicle Use (Vehicles/hour)	Bulldozer Operation (% of observation period)
Hobart	41	18
Lauderdale	24	19
Margate	15	35

(i) Hobart tip. The Hobart tip was the largest of the three regularly surveyed tips. It is situated near the head of McRobie's Gully, 3.5 km in a direct line from the Derwent estuary. Figure 4.3 is a sketch-map of the general layout of the tip during the study.

Roughly triangular in shape, the tip area was bounded on two sides by the gully slopes, which supported open forest; a high cyclone fence on the third side separated the tip from a low, open area. Vehicular entry was through a gate in this fence, and the track then passed over an elevated layer of previously compacted and covered rubbish to the tip face where rubbish was dumped under the supervision of Hobart City Council employees. The actual tip face was about 4 m high and about 30 m wide, and was the site of most feeding by gulls.

When not feeding, the gulls rested at areas of the tip where they could remain relatively undisturbed by vehicles or people. These sites have been designated as "loafing areas" following the nomenclature adopted overseas. Figure 4.3 indicates the three areas used for loafing by gulls at the Hobart tip. Area A was a cleared ledge 4 m up the slope above the tip, while Areas B and C were largely flat areas below the raised area of the tip and contained

FIGURE 4.3

Typical Layout of Hobart Tip During the Study Period

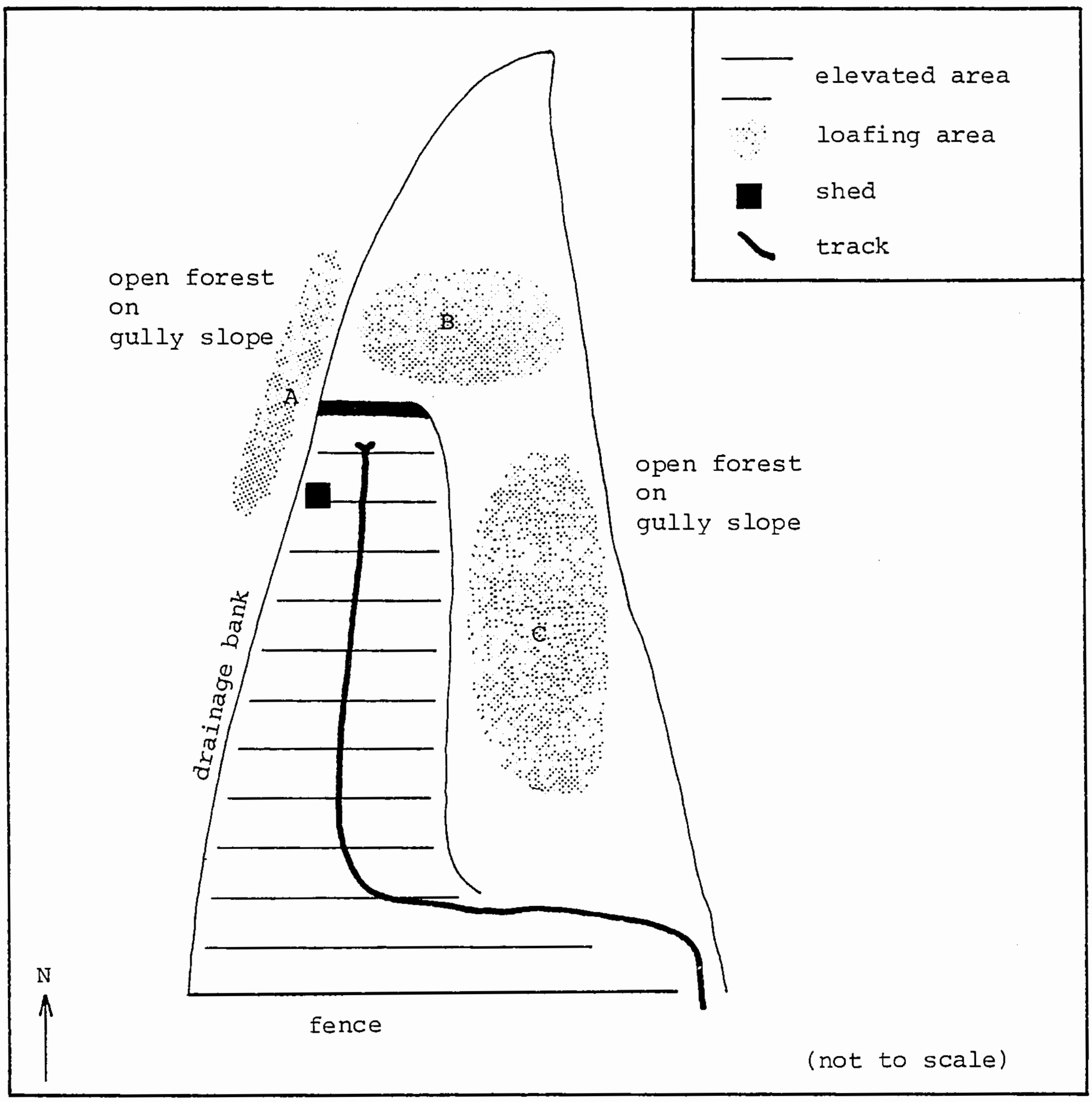


FIGURE 4.4

Typical Layout of Lauderdale Tip During the Study Period

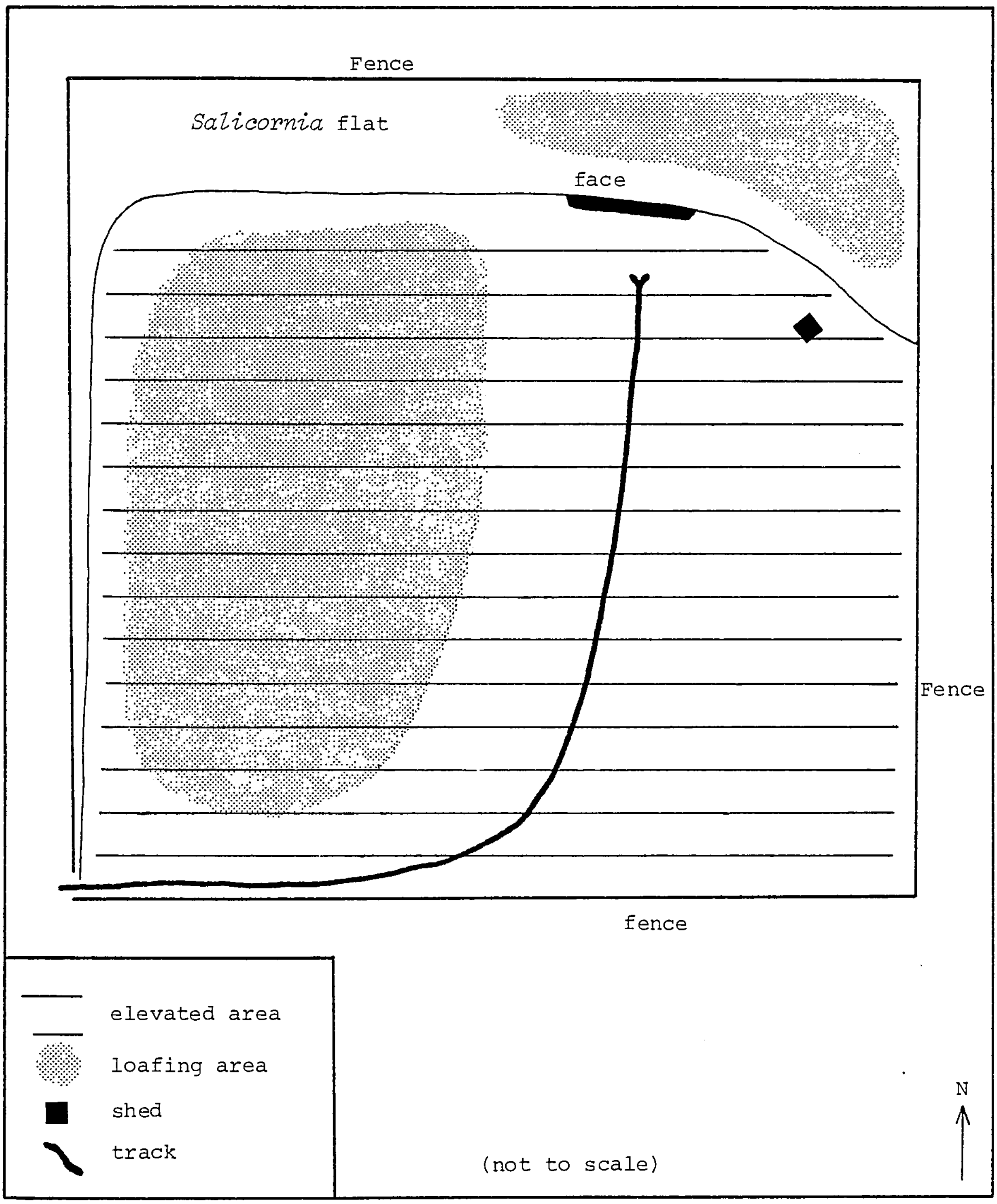
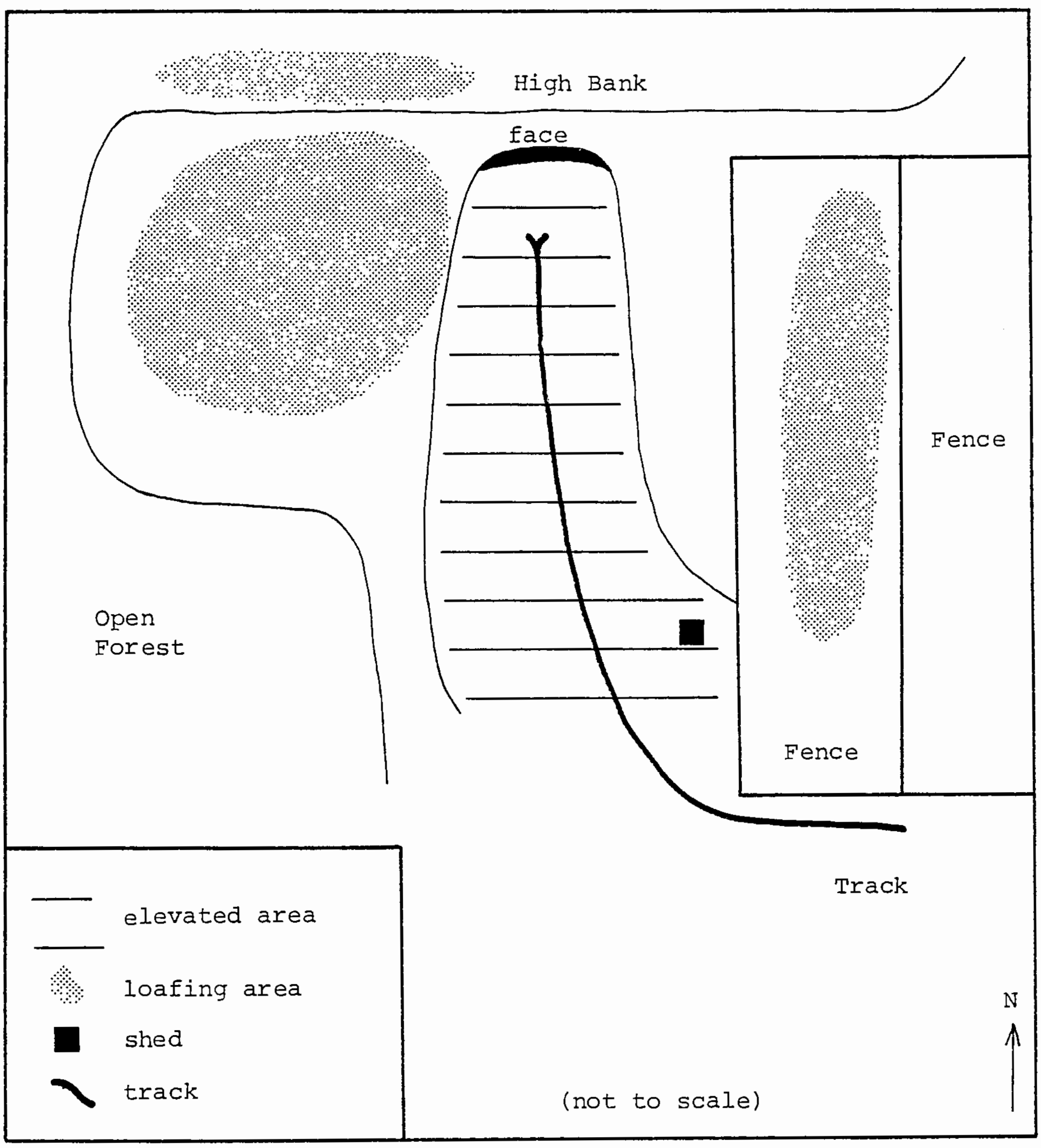


FIGURE 4.5

Typical Layout of Margate Tip During the Study Period



shallow puddles of water after rain. Areas A and B were favoured by Kelp and Pacific Gulls, while Area C was used mainly by Silver Gulls. The behaviour of gulls at the tip is described in detail in Section 4.4.1.

(ii) Lauderdale tip. Situated on low saltmarsh, only 200 m from Ralphs Bay, Lauderdale tip also differed from both Hobart and Margate tips in having no surrounding trees. The tip area was delineated only by a 3 m high cyclone netting fence and is sketched in Figure 4.4. About two-thirds of the enclosed space had already been covered by a layer of compacted rubbish and earth, and consequently was 2-3 m higher than the remaining low land.

Under the direction of the tip supervisor, tipping occurred over a relatively narrow face (about 10 m wide) at any one time. There were two distinct loafing areas within the tip boundary; one on the completed, raised level and the other on the *Salicornia* below the tip face. At times many birds also loafed on the *Salicornia* beyond the fence where there was a dam.

(iii) Margate tip. The layout of the Margate tip is shown in Figure 4.5. This tip differed from Hobart and Lauderdale tips in that tipping occurred at various times around a compacted tongue-shaped area, and earth covering was derived from the site itself, which entailed considerably more bulldozer activity. Three distinct loafing areas were used: one was in a cleared, fenced enclosure beside the tip workings, another overlooking the tip on a high bank, and the third on a clear area containing puddles below the elevated level of the completed layer of rubbish and earth.

(b) Shoreline sites. We initially selected 21 sites to sample a range of gull habitats, including tidal flats and muddy, sandy and rocky shores, as well as man-made structures including boat ramps, boats ranging in size from small dinghies to ocean-going vessels, and piers ranging from small wooden jetties to large concrete wharves. The main structural features of each site are indicated in Table 4.6 and the locations of the sites are shown in Figure 4.6. An additional site (V) was added later in the study.

The sites were all near urban areas of Hobart or small settlements, and some were adjacent to industrial zones. The topography of Sites E to U has been described by Guiler (1949), and Site V is at the entrance to Pipeclay Lagoon which has been described by Guiler (1950). Aquatic food supply was augmented by human activity at some sites: Site A was a fish processing plant with an outfall which sometimes attracted flocks of gulls, Site E was the main Hobart docks where anglers occasionally fed scraps to gulls, the abbattoir at site J had an outfall where gulls always congregated, and Site V was the base for an amateur fishery which regularly provided numerous scraps for sizeable flocks of gulls.

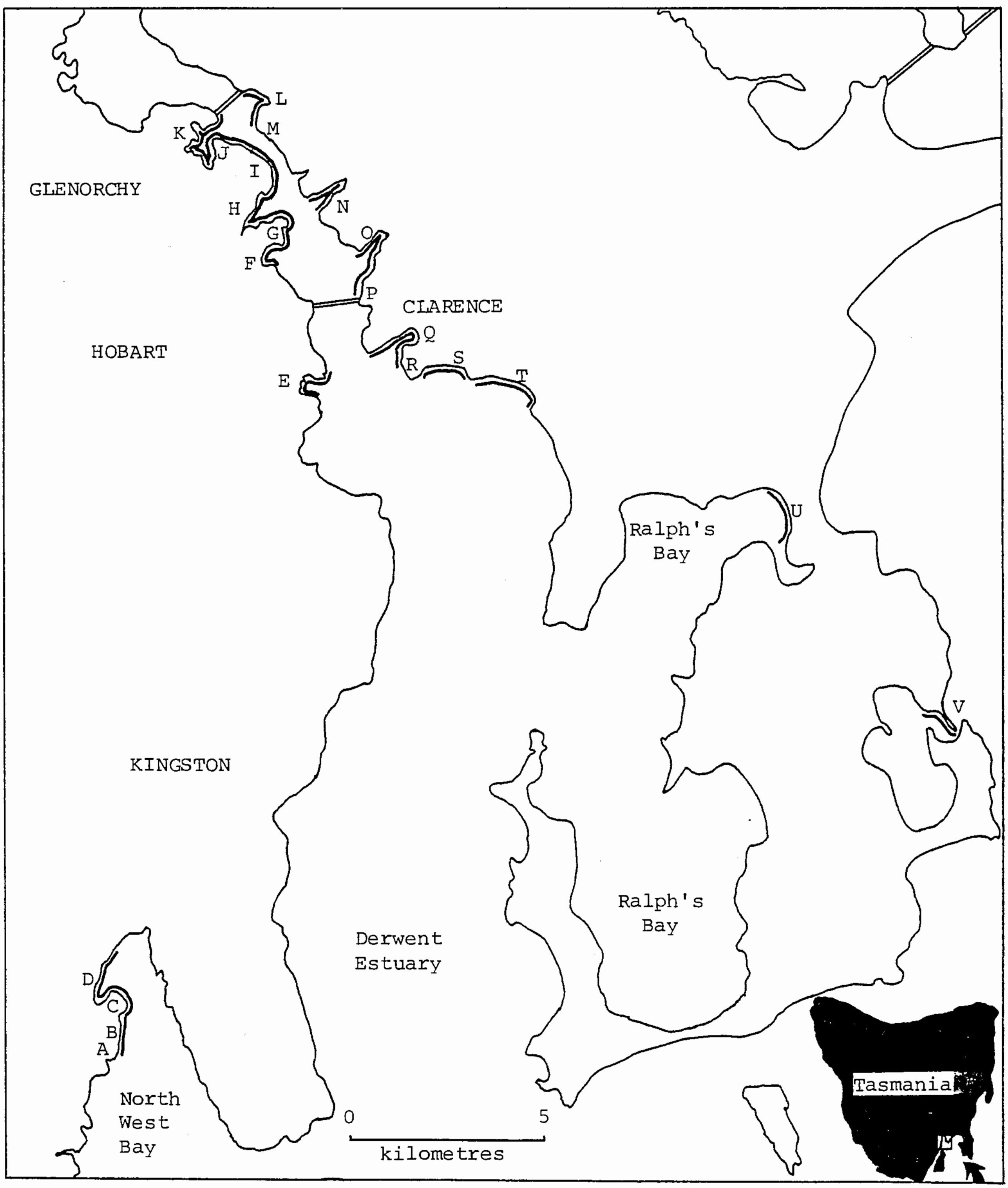
TABLE 4.6

Main Structural Features of the Shoreline Sites Surveyed for Gulls in South-East Tasmania

Site	Mud	Rocks	Sand	Tidal flat	Piers and Ramps	Boats	Comments
A. Safcol	•	•			•	•	Fish cannery, processing
B. Margate foreshore		•			•	•	
C. Dru Point		•			•		
D. North arm, North West Bay	•			•			
E. Sullivan's Cove					•	•	
F. Cornelian Bay		•	•		•	•	
G. Self's Point		•			•		Petroleum terminal, sewage t/ment plant
H. Newtown Bay	•	•			•	•	
I. Zinc works		•			•		
J. Abattoir		•	•				Abattoir
K. Prince of Wales Bay	•	•			•	•	
L. Risdon Cove	•			•			
M. Church Point		•					
N. Geilston Bay	•	•			•	•	
O. Lindisfarne Bay		•		•	•	•	
P. Rose Bay		•	•				
Q. Kangaroo Bay		•			•	•	
R. Bellerive Rocks		•			•		
S. Bellerive Beach		•	•				
T. Howrah Beach		•	•				
U. North Ralph's Bay		•	•				Extensive tidal flat, opposite tip
V. Cremorne		•	•	•	•	•	Amateur fishing

FIGURE 4.6

Location of Shoreline Sites Surveyed in South-East Tasmania



4.2.2 Method of gull survey

Over the four month period from the beginning of June to the end of September 1981, gulls were counted regularly at three large tips in south-east Tasmania. Lauderdale and Margate tips were visited weekly and Hobart tip three times weekly during this period. Almost all of these counts were conducted between 0900 and 1200 hours, on days from Monday to Friday inclusive. Since it was extremely difficult to count the gulls while they were actively feeding, we waited until they were disturbed from the tip face and then counted them at rest on the loafing area. Occasionally there was so much movement of gulls that we were unable to obtain a complete count. This was most likely to occur at Lauderdale tip, where more frequent bulldozing activity excited the gulls so that counting was sometimes impossible, although behavioural observations could be made (see Section 4.3).

The shoreline sites were surveyed in the morning or early afternoon once per week from mid-June to September. Sites A to D were surveyed on the same day as visits to Margate tip, surveys of Sites E to P coincided with one of the three weekly visits to Hobart tip and Sites Q to W were combined with visits to Lauderdale tip. The sites were visited by vehicle and surveyed from vantage points. We recorded the location of each gull when first sighted.

Kelp and Pacific Gulls were assigned to broad age classes, mainly on the basis of their plumage (see Sections 3.2.2 and 3.3.2). Three categories were defined:

i) juvenile birds which had overall brown plumage and so were in their first year;
ii) sub-adult birds, which had a mottled appearance with varying amounts of brown, black and white in their plumage and would have been predominantly second and third year birds but may have included some birds in their fourth year;
iii) adult birds, which had pure black and white plumage.

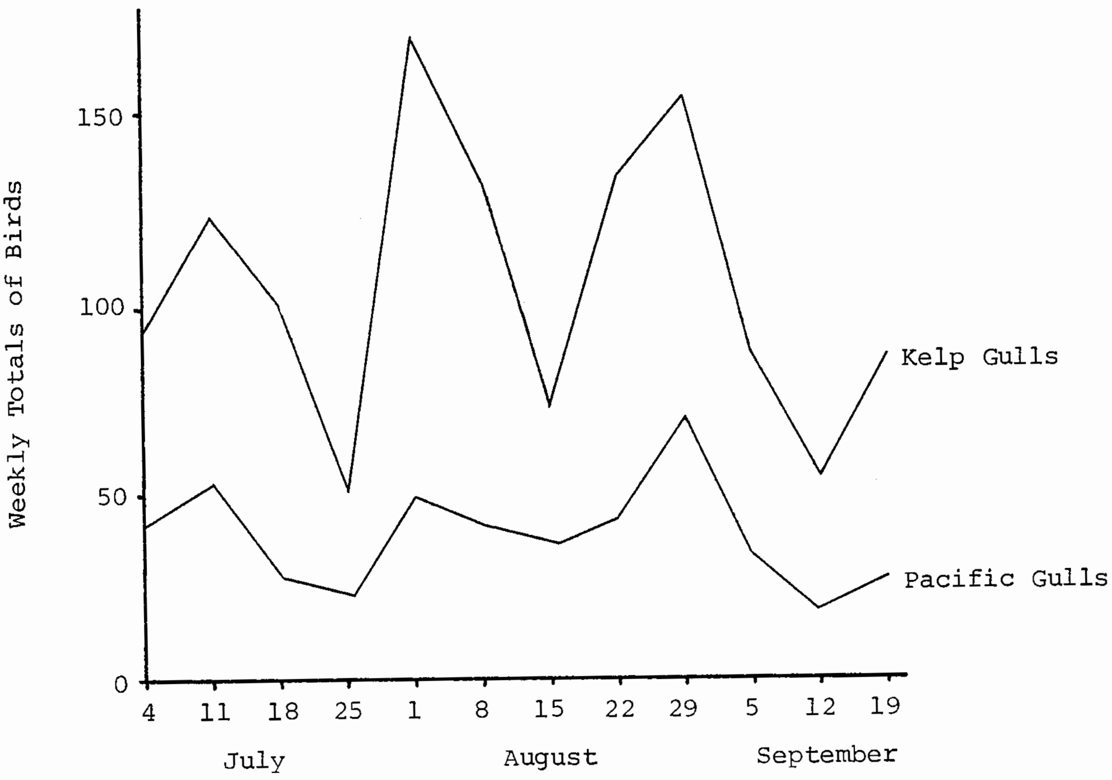
Where possible, both legs of each large gull were examined to determine the presence of metal and/or coloured plastic bands. The particular leg carrying the band and the colour of any plastic bands were noted. Birds whose legs were concealed were listed as uncertain, to distinguish them from unbanded birds. This band data was applicable mainly with Kelp Gulls, due to the banding programme carried out by the Shorebird Study Group of the Bird Observers Association of Tasmania (see Section 3.3.4), but a few banded Pacific Gulls were also observed. The greater distances involved at most shoreline sites made it difficult to detect bands so most birds at these sites were listed as uncertain.

4.2.3 Temporal changes in gull numbers

(a) Shoreline sites. The total numbers of large gulls recorded at shoreline sites each week are given in Figure 4.7. The numbers show considerable fluctuation over the study period with no obvious trend over the study period for either Kelp or Pacific Gulls.

FIGURE 4.7

Total Numbers of Kelp and Pacific Gulls per Week in Winter at Shoreline Sites in South-East Tasmania



Additional surveys earlier and later in the year might have enabled us to detect a long-term seasonal pattern, particularly in response to the breeding season. Fordham (1968) conducted monthly surveys of Kelp Gull numbers in Wellington Harbour, New Zealand, over three and a half years, and found that they peaked in autumn and fell during winter and spring to their lowest level in summer, before increasing sharply at the end of the breeding season the following autumn. The proportion of adults in the flocks declined steadily from autumn to summer and the proportion of juveniles increased. Fordham's survey area covered a variety of habitats ranging from uninhabited shorelines to the artificial feeding sites provided by meatworks and rubbish tips. Approximately 60% of the birds were located at these artificial sites, so Fordham's findings are not directly comparable with our results from the shoreline sites in south-east Tasmania. A seasonal pattern was also recorded by Watson (1955) who monitored the Pacific Gulls at one beach in Victoria over a three-year period and found that numbers peaked in winter and again in summer, and this pattern was most noticeable in immature (juvenile plus sub-adult) birds.

The changes in age structure of large gulls at our shoreline sites are detailed in Tables 4.7 and 4.8. Kelp Gulls were similar in age structure in June and July, then the percentage of juveniles increased in August and the percentage of adults fell proportionately. In September the age structure reverted to the earlier pattern with the exception that the percentage of sub-adults had fallen to less than half of its previous value.

TABLE 4.7

Monthly Percentage of each Age Class of Kelp Gulls at Shoreline Sites in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	19.4	11.6	69.0
July	18.6	12.0	69.4
August	39.0	13.8	47.2
September	25.5	4.7	69.8

TABLE 4.8

Monthly Percentage of each Age Class of Pacific Gulls at Shoreline Sites in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	34.4	9.4	56.3
July	46.9	8.1	45.0
August	47.9	8.1	44.1
September	40.2	4.9	54.9

Part of this change in September can be accounted for by changes in plumage during winter. This could be examined by comparing birds which had been colour-banded (see Section 3.3.4), and were therefore of known age, with their allocation to age classes on the basis of plumage characteristics (see Section 4.2.2). Data collected at the three large tips were pooled for this analysis. Table 4.9 indicates the percentage of birds with colour bands which were classified into each of the three age classes. All green-banded (first year) and blue-banded (second year) birds were correctly allocated to the juvenile and sub-adult age classes respectively. Birds with black bands (third year) and orange bands (fourth year) were recorded as both sub-adults and adults, and the percentage of birds allocated to the adult age class increased during the study period. This finding indicates that a proportion of birds which were assigned to the sub-adult class early in the study period would have later been recorded as adults. This would contribute to the lower proportion of sub-adults and higher proportion of adults recorded in September. However, juveniles did not change their plumage during this period so it is difficult to account for their proportional change in August and September.

Pacific Gulls exhibited a more stable pattern of age structure over the four month period. Table 4.8 indicates that the proportion of juveniles was highest in July and August whereas adults were most common in June and September. Some sub-adults may have attained adult plumage to account for their decrease and a corresponding increase for adults in September, but Pacific Gulls had not been colour-banded so we could not examine plumage changes in birds of known age. The higher proportion of juveniles in July and August is broadly similar to the winter peak noted by Watson (1955) although her peak occurred somewhat earlier in winter. The reasons for this pattern are not clear.

TABLE 4.9

Percentage Allocation of Colour-Banded Kelp Gulls to Age Classes
Based on Plumage Characteristics

Band Colour	Age Class	Allocation to Age Class (%)			
		June	July	August	September
Green	juvenile	100	100	100	100
	sub-adult	0	0	0	0
Blue	sub-adult	100	100	100	100
	adult	0	0	0	0
Black	sub-adult	43	39	17	0
	adult	57	61	83	100
Orange	sub-adult	22	17	0	0
	adult	78	83	100	100

(b) Rubbish tips. The numbers of Silver, Kelp and Pacific Gulls recorded at the three large tips each week from June to September are shown in Figures 4.8, 4.9 and 4.10. Values for Hobart tip are the means of the three counts for each week. Additional counts obtained during irregular visits to the tips before and after the main study period are also shown.

Silver Gulls were by far the most numerous gull species at all three tips. The number of Silver Gulls present at any particular tip fluctuated considerably from week to week, and no clear overall pattern was discernible, although numbers tended to be low at the beginning and end of the year and higher during the winter months.

Wide fluctuations in numbers also occurred with Kelp and Pacific Gulls. Such weekly variations may have been related to tide and weather conditions which are discussed later in this section. Seasonal trends were more marked in Kelp and Pacific Gull numbers, particularly at Hobart and Margate tips where numbers of both species built up from initially low levels, were highest in June and July and had declined to consistently lower levels by August. This pattern was not so evident at Lauderdale tip where numbers of both species appeared to show a second peak in late August. However,

FIGURE 4.8

Mean Numbers of Silver, Kelp and Pacific Gulls per Week at Hobart Tip

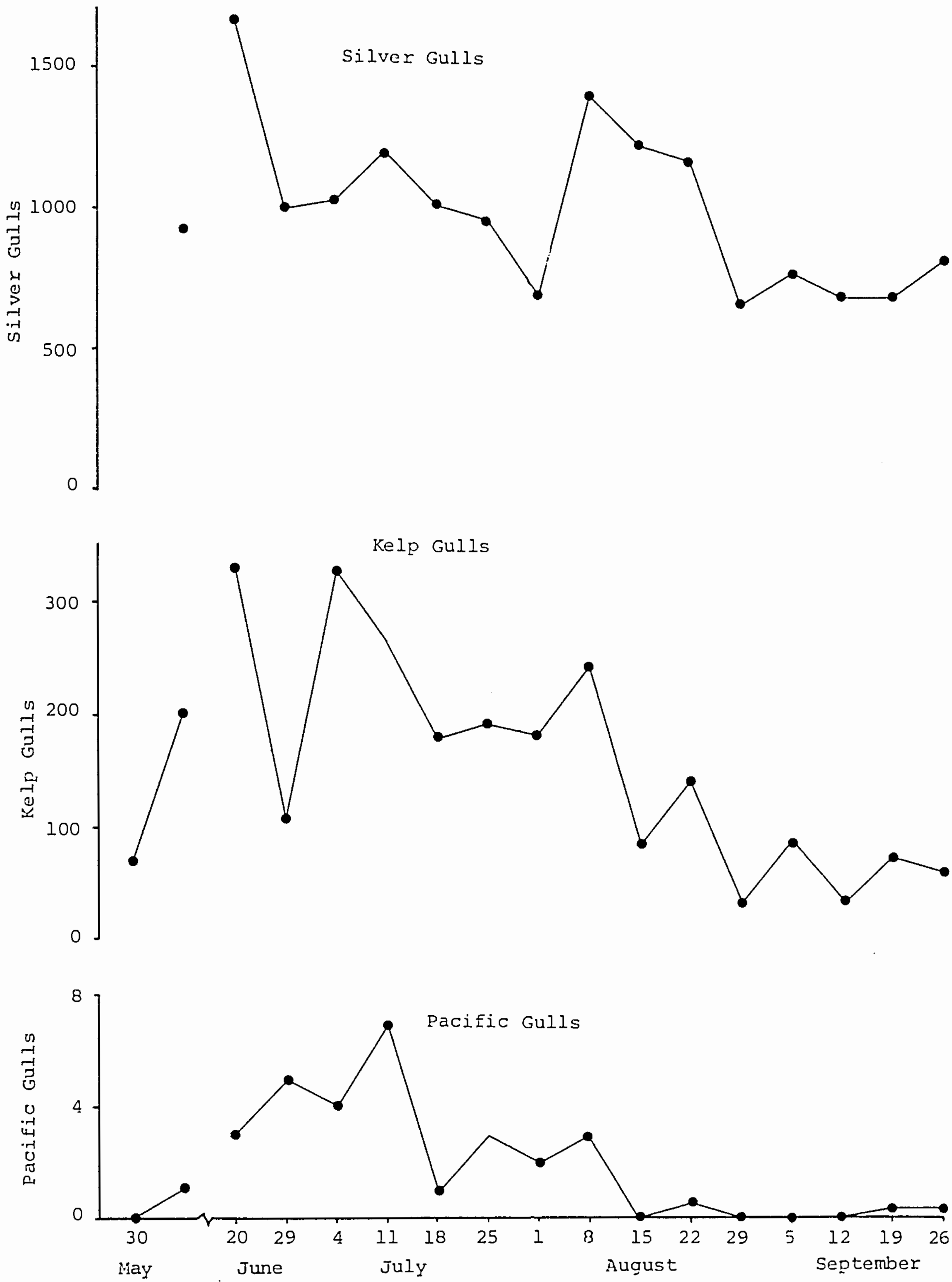


FIGURE 4.9

Total Numbers of Silver, Kelp and Pacific Gulls per Week at Lauderdale Tip

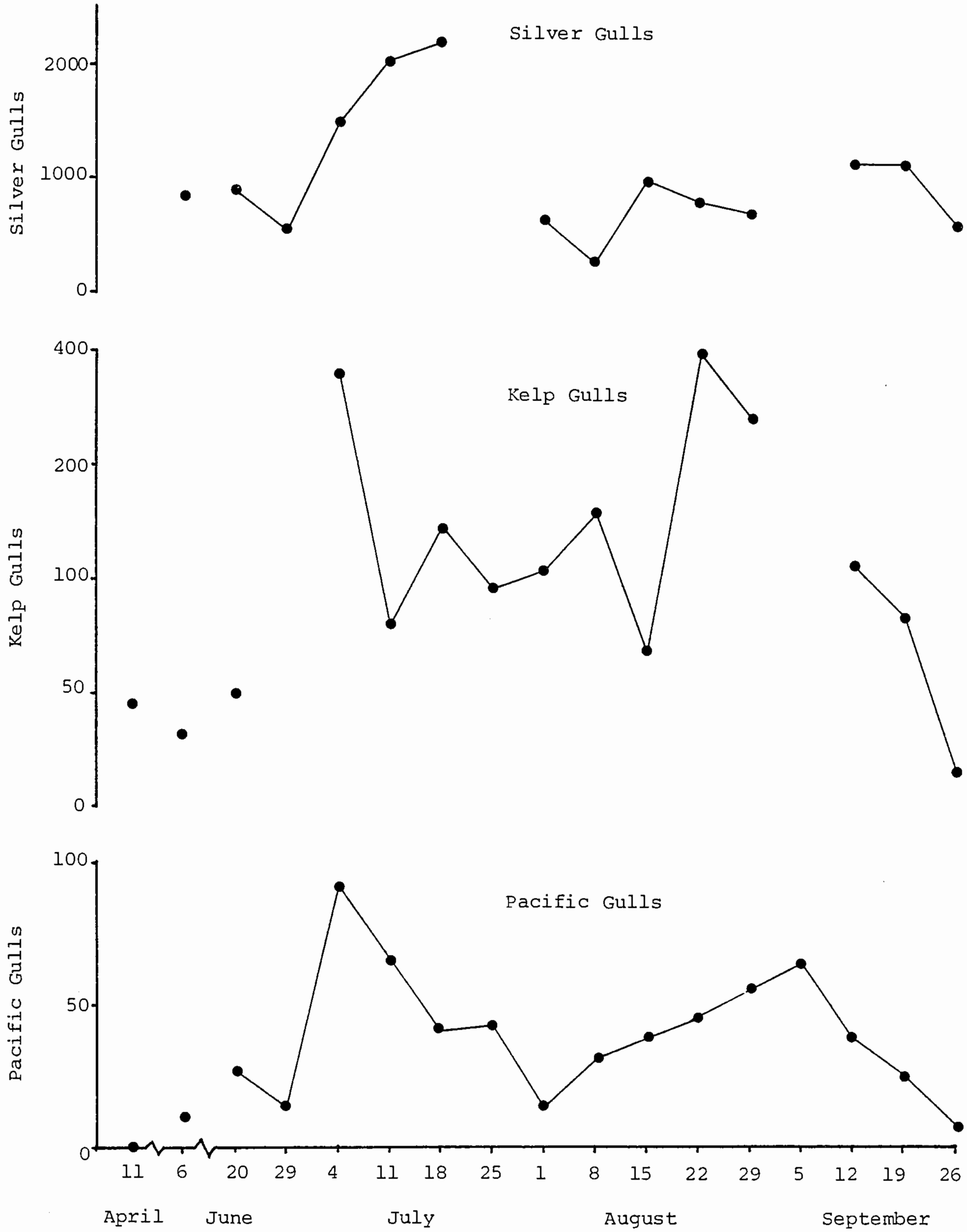
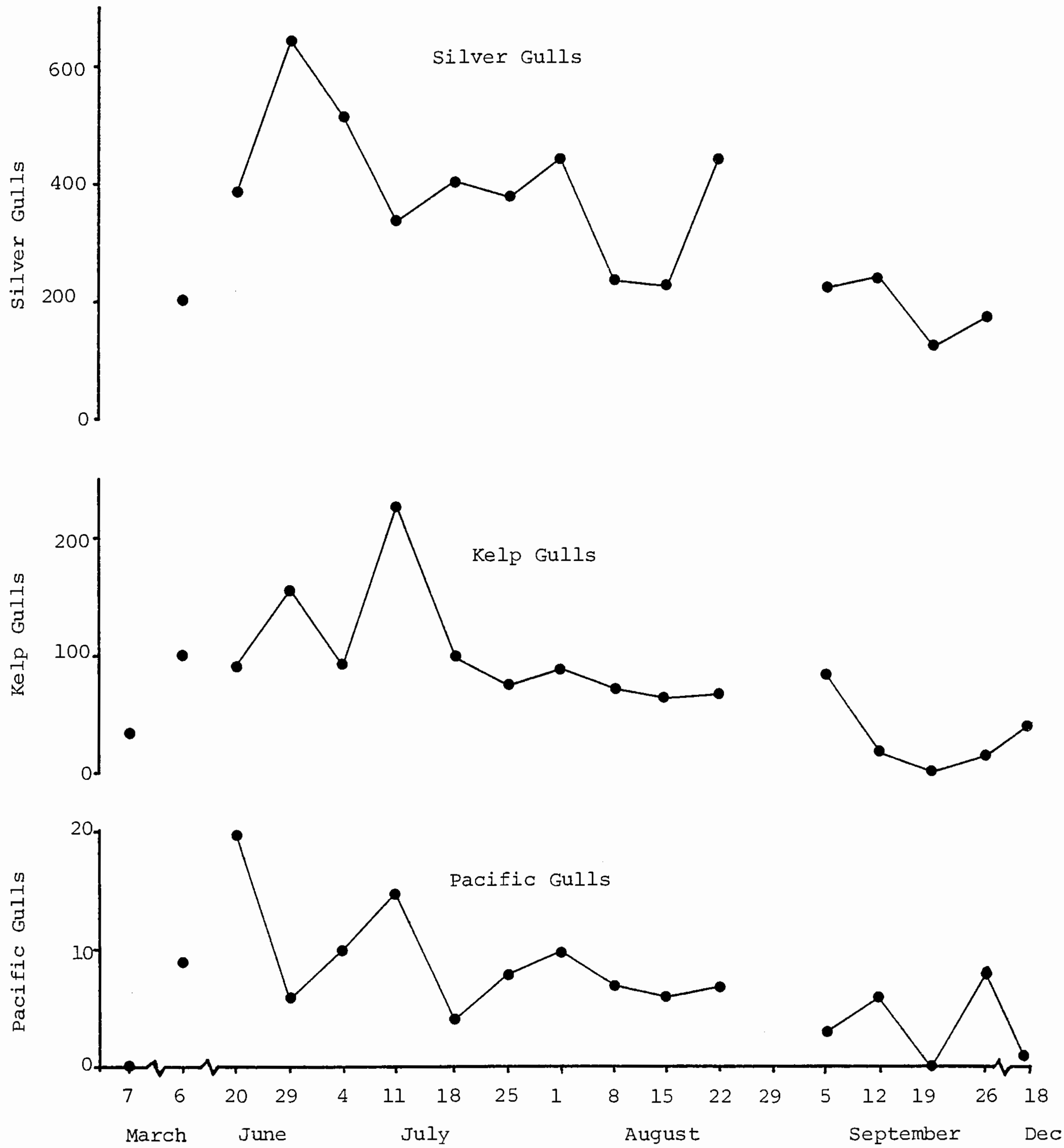


FIGURE 4.10

Total Numbers of Silver, Kelp and Pacific Gulls per Week at Margate Tip



numbers of Kelp and Pacific Gulls at Lauderdale tip did decline to low levels in September. This pattern is consistent with the finding by Spaans (1971) that the numbers of Herring Gulls at tips in the Netherlands decreased during the breeding season. Similarly, Monaghan (1980) reported that the numbers of Herring Gulls at a tip in England declined in late winter/early spring. She found that the adults departed for their breeding colonies at this time while the numbers of immature (juvenile and sub-adult) birds remained relatively constant.

Tables 4.10, 4.11 and 4.12 give the monthly age structure at the three large tips for Kelp Gulls. At Hobart tip the percentages of each age class remain relatively constant throughout winter, then the proportion of adults rises and that of juveniles and sub-adults falls in September. Almost the same pattern was seen at Lauderdale tip, except that the September rise in proportion of adults was preceded by a fall in August as was recorded at shoreline sites and discussed in part (a) of this section. Part of this pattern can be accounted for by a proportion of sub-adults undergoing changes into adult plumage. However, this cannot explain the decreased proportion of juveniles. Thus, the fall in overall numbers in

TABLE 4.10

Monthly Percentage of each Age Class of Kelp Gulls at Hobart Tip in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	34.1	24.8	41.1
July	30.1	24.5	45.5
August	31.7	24.9	43.4
September	9.2	12.1	78.8

early spring at Hobart and Lauderdale tips cannot be simply explained as the beginning of a move to the breeding colonies because proportionately more of the departing birds were immature. At Margate tip the age structure was virtually unchanged over the study period with the exception of a fall in the percentage of sub-adults in September, as at the other two tips, which to some extent would be due to changes in plumage.

TABLE 4.11

Monthly Percentage of each Age Class of Kelp Gulls at Lauderdale Tip in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	19.1	17.3	63.6
July	13.4	18.6	68.0
August	27.7	20.7	51.6
September	8.6	7.1	84.2

TABLE 4.12

Monthly Percentage of each Age Class of Kelp Gulls at Margate Tip in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	12.0	8.6	79.4
July	9.1	12.7	78.2
August	10.2	8.3	81.2
September	12.3	3.8	84.0

The pattern of age structure changes exhibited by Pacific Gulls over the study period was essentially the same as the results presented for Kelp Gulls. The monthly age structures at Lauderdale and Margate tips are presented in Tables 4.13 and 4.14. At Hobart tip all except two of the Pacific Gulls recorded were juveniles, so no age structure analysis was performed. The percentage of adults at Lauderdale was virtually constant during winter, then increased in September when the percentage of juveniles fell. At Margate the percentage of adults was not as consistent during winter, but also rose in September and the percentage of juveniles fell accordingly.

In general, both Kelp and Pacific Gulls displayed changes in age structure which indicated that juveniles ceased to feed at these sites proportionately more than adults at the beginning of spring. The reasons for this change are obscure, and it is not apparent what alternative feeding sites are used. The young birds did not move into the shoreline sites monitored in this study because the proportion of juvenile Kelp Gulls at these sites also fell in September and the proportion of juvenile Pacific Gulls did not change. It seems probable that juveniles of both species which had fed at tips during winter began to disperse widely in spring.

TABLE 4.13

Monthly Percentages of each Age Class of Pacific Gulls at Lauderdale Tip in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	65.8	7.9	26.3
July	55.4	17.1	27.5
August	61.3	15.0	23.7
September	42.6	17.0	40.3

TABLE 4.14

Monthly Percentages of each Age Class of Pacific Gulls at Margate Tip in Winter

Month	Proportion of Birds in each Age Class (%)		
	Juvenile	Sub-Adult	Adult
June	52.6	15.8	31.6
July	81.1	5.4	13.5
August	80.0	0.0	20.0
September	52.9	0.0	47.1

It is probable that gulls increasingly feed at tips in winter because the deteriorating foraging conditions at natural sites correspond with a period of increased metabolic stress during winter. Increased tidal range and improved weather conditions may make gulls more likely to feed away from tips in spring.

Exogenous environmental factors have been found to affect the behaviour of gulls in several northern hemisphere studies. Kihlman and Larsson (1974) found that the number of Herring Gulls at tips in Sweden was positively correlated with air temperature, water level and wind strength, and negatively correlated with air pressure. Because these factors were themselves inter-related, the authors concluded that the influence on gull numbers could possibly be reduced to a correlation with water level which was probably important to the birds because of the increased feeding opportunities available at low tide. Similarly, Spaans (1971, 1975) and Verbeek (1977a) found that the number of gulls at tips fluctuated according to the feeding possibilities on tidal flats as influenced by tide and weather conditions. Wind direction early in the morning of the count was an important factor affecting the number of Herring Gulls at tips in Monaghan's (1978) study. The number and behaviour of gulls on breeding colonies have also been found to be related to tidal and weather factors (Drent, 1967; Delius, 1970; Galusha and Amlaner, 1978).

To test the effect of weather conditions on the number of gulls using tips in south-east Tasmania, we collected data on a number of meteorological variables and correlated this with the number of birds at each tip. It was not possible to correlate gull numbers in shoreline sites with tidal and weather variables because partial counts made on three separate days were pooled to give the weekly totals.

Ten selected environmental measurements were collected for each count made at the three tips. The time of day at which each count was made was converted into minutes after sunrise for analysis, since Pacific and Kelp Gulls are diurnal (see Sections 3.2.4 and 3.3.4). Wind, air temperature, air pressure and tide factors were determined for both the actual time when the count was made, and for sunrise on the day of the count because we considered that such cues could affect the path taken by birds as they left the roost at dawn. Access to continuous tide records for the port of Hobart was provided by the Hobart Marine Board, and these levels were considered to be applicable to all three tips. The tide measurements were recorded to within 0.01 of a metre. The Meteorological Bureau of Hobart provided access to weather records. Rainfall is measured to the nearest 2 mm, and figures are collected for the 24 hour period from 9 a.m. This means that the rainfall figures used for each count were for rain which fell on the previous day, overnight and early on the morning of the count. The other weather factors were recorded hourly, so the figures used for analysis were for the hour nearest to sunrise or the time of the count. Wind speed is measured to the nearest knot and wind direction specified according to a 16 point compass. For sunrise on the day of each count, the wind speed and direction were combined to form a single vector measurement which was resolved along the likely flight line from roost to tip. Green Island was considered to be the main roost for gulls using Margate and Hobart tips, which are both due north from the island. Lauderdale tip is approximately 30^{o} west of north from Pipeclay Lagoon which is the likely major roost for large gulls in that area. These flight lines are shown in Figure 4.1. Wind speed alone was considered at the time of the count, because we had no way of determining the direction of flight to a tip during the day. Temperature was recorded to the nearest $0.1^{o}C$, and air pressure to within 0.1 mbar.

The coefficients of correlation between tide and weather variables and Pacific and Kelp Gulls at Hobart tip are shown in Table 4.15. These tests were not made with Silver Gull numbers. There was a significant negative correlation between the air temperature at sunrise and numbers of both Pacific and Kelp Gulls, and between air temperature at the time of the count and the number of Kelp Gulls. No correlations even approaching significance were obtained between any of the other environmental variables and gull numbers, although except for rainfall the variables were themselves largely inter-correlated as shown in Table 4.15. In particular, tide levels both at sunrise and at the time of the count were significantly correlated with wind speed and with air pressure at both times, yet none of these five variables was significantly related to the number of gulls present at Hobart tip. Although tide at the time of the count was positively correlated with both temperature measurements, tide at sunrise was not related to either temperature. Since temperature was the only factor significantly correlated with gull numbers, and the temperature at sunrise was better correlated with the numbers of both Pacific and Kelp Gulls than was the temperature at the time of the count, this further suggests that tide was not an important factor affecting the likelihood of gulls to visit Hobart tip.

The fact that more birds of both species were at the tip when temperatures were low could be interpreted as a function of time, both seasonally and daily. The monthly mean air temperatures recorded at sunrise on the days when surveys were conducted at Hobart tip are shown in Table 4.16. Air temperatures were on average much higher in September, when the numbers of gulls were relatively low (Figure 4.8).

TABLE 4.15

Coefficients of Correlation between Environmental Variables and Numbers of Pacific and Kelp Gulls at Hobart Tip

		Measurements at Sunrise				Measurements at Time of Count				Rainfall (mm)	Number of Pacific Gulls	Number of Kelp Gulls
		Wind Vector (knots North)	Air Temperature (°C)	Air Pressure (mbar)	Tide Level (m)	Wind Speed (knots)	Air Temperature (°C)	Air Pressure (mbar)	Tide Level (m)			
Measurement at Sunrise	Wind vector (knots north)	1	-0.37*	0.28	-0.22	-0.37*	-0.42**	0.27	-0.24	0.22	0.09	0.12
	Air temperature (°C)		1	-0.37*	0.22	0.44***	0.80***	-0.31	0.38**	0.05	-0.35*	-0.36*
	Air pressure (mbar)			1	-0.46***	-0.38**	-0.18	0.97***	-0.62***	-0.11	0.10	0.01
	Tide level (m)				1	0.33*	0.25	-0.46***	0.41**	0.23	-0.29	-0.11
Measurement at Time of Count	Wind speed (knots)					1	0.46	-0.39**	0.51***	0.20	-0.06	-0.12
	Air temperature (°C)						1	-0.19	0.38**	-0.12	-0.30	-0.33*
	Air pressure (mbar)							1	-0.57***	-0.10	0.09	0.02
	Tide level (m)								1	0.04	-0.04	0.06
Rainfall										1	-0.07	-0.10

*** $p < 0.01$
** $0.01 < p < 0.02$
* $0.02 < p < 0.05$

35 d.f., 2-tailed test

At the daily level, air temperature would be expected to rise during the morning after a minimum at sunrise, so that a negative correlation with air temperature at the time of the count could conceivably reflect a decline in gull numbers over the morning. This does not appear to be the case with Pacific or Kelp Gulls at Hobart tip, since neither species was significantly correlated with the time of day when the count was made. In fact, very limited observation of movements of gulls to and from the tip suggested that total numbers of large gulls increased somewhat over the morning (see Section 4.3.1).

However, the number of Silver Gulls recorded at Hobart tip was negatively related to the time of day ($p < 0.01$, 35 d.f., 2-tailed test), implying that Silver Gull numbers peaked early in the morning and declined thereafter. This difference between the species is probably related to their feeding behaviour. Silver Gulls obtain food more quickly at tips than do large gulls (see Section 4.3.1).

TABLE 4.16

Mean Sunrise Air Temperature in Hobart on Days when Surveys Conducted at Hobart Tip

Month	Temperature (^{o}C)
June	6.6
July	5.6
August	6.0
September	11.1

No significant correlations were found between gull numbers and any of the tidal and weather variables at Margate and Lauderdale tips. This could have been due to the relatively low numbers of visits made to those two tips. The relationship between Kelp Gull numbers and air temperature at the time of the count was negative and almost significant at Margate tip, so there may have been an underlying relationship between numbers and temperature as found at Hobart tip.

Kelp Gull numbers were not significantly related to the time of day when the count was made at either Margate or Lauderdale tips, but Pacific Gull numbers were positively correlated with time ($0.02 < p < 0.05$) at Margate tip. The reason for this is not clear. There were negative but not significant correlations between the numbers of Silver Gulls and time at both Margate and Lauderdale tips, so it is possible that the time of day relationship apparent with Silver Gulls at Hobart tip also applies at the other two tips. The lack of significance is probably accounted for by the comparatively low number of observations made at Margate and Lauderdale tips.

The only significant correlations between environmental variables and numbers of large gulls were the negative relationships between air temperature and the number of Kelp and Pacific Gulls present at Hobart tip. As discussed earlier, this probably reflects a seasonal trend to declining reliance on tips in spring with its warmer days. While they were significant, these correlations were low (0.33, 0.35 and 0.36), so temperature accounted for only about 10% of the variance in Kelp and Pacific Gull numbers.

The total numbers of each species were themselves much better correlated with each other ($r = 0.69$ at Hobart tip, $r = 0.77$ at Lauderdale tip, both $p < 0.01$; $r = 0.40$ at Margate tip, not significant). The two species may be responding to the presence of each other; gulls are known to be attracted by the sight of other gulls (Ward and Zahavi, 1973). Additionally, both species could be influenced by the same exogenous conditions, which were largely undetected by our analysis. It may have been advantageous to have included a measure of tidal range in the list of parameters investigated. Because of the time limitations of our study, the range of tide and weather conditions sampled was not large. Greater sampling frequency and especially sampling over more than one season may well have detected further relationships between environmental factors and the numbers of Kelp and Pacific Gulls at tips, and confirmed the role of temperature as one determinant of gull behaviour.

At present it is not possible to isolate the causal factors responsible for the day to day fluctuations in gull numbers at the three tips. These fluctuations might simply reflect stochastic variation, as groups of birds enter and leave the tips; this may be overlain by immediate responses to local changes in the tips, such as disturbance on the loafing areas. These patterns are discussed in Section 4.3.1.

4.2.4 *Comparison of gull numbers at different feeding sites*

(a) Species ratios. Kelp and Pacific Gulls were not evenly distributed throughout the survey areas. Their numbers were most concentrated at the three large tips, and also the abattoirs (Site J), Ralph's Bay near Lauderdale tip (Site U) and Cremorne (Site V). Table 4.17 details the mean numbers of Kelp and Pacific Gulls recorded in each visit to these sites.

TABLE 4.17

Mean Numbers of Kelp and Pacific Gulls Recorded per Week at Shoreline Sites

Site	Mean Number of Birds	
	Kelp Gulls	Pacific Gulls
A	1.0	0.8
B	2.8	3.2
C	2.1	0.1
D	14.2	0.2
E	0.4	1.4
F	0.4	0.4
G	1.1	1.1
H	0.1	0.1
I	3.7	0.4
J	8.6	3.3
K	1.4	1.3
L	0.0	0.5
M	0.4	0.3
N	0.0	0.1
O	0.1	1.7
P	0.8	0.1
Q	0.2	1.0
R	2.6	1.5
S	0.0	0.7
T	1.8	0.8
U	59.6	19.5
V	8.6	15.4

The ratios of Kelp to Pacific Gulls recorded at the study sites between June and September are given in Table 4.18. The ratios have been calculated for each of the three large tips and for the combined shoreline feeding sites. The three shoreline sites which had the greatest concentrations of large gulls are also presented separately. In addition, Table 4.18 gives the ratios of the two species obtained during the Bird Observers Association of Tasmania's census of large gulls taken in June 1980 and 1981 (from Tables 3.4 and 3.14).

TABLE 4.18

Ratios of Kelp to Pacific Gulls at Feeding Sites and from June Censuses in South-East Tasmania

Locality	Kelp : Pacific Ratio
Hobart tip	88.9 : 1
Lauderdale tip	5.4 : 1
Margate tip	11.8 : 1
All shoreline sites (excluding Cremorne)	2.8 : 1
Abattoir (Sites I and J)	3.7 : 1
North Ralph's Bay	3.1 : 1
Cremorne	0.6 : 1
1980 June census	3.1 : 1
1981 June census	4.4 : 1

The ratios from the June census may be taken to represent the overall proportions of the two species in south-east Tasmania: Kelp Gulls outnumber Pacific Gulls by approximately 4:1. Any marked deviations from that ratio at sites within the south-east can then be interpreted as indicating a preference for that site. On this basis, Hobart tip is overwhelmingly preferred by Kelp Gulls, and they also show a lesser but marked preference for Margate tip. In contrast, Lauderdale tip may have been only slightly preferred by Kelp Gulls because although it was visited by large numbers of Kelp Gulls, it was also the only tip which attracted relatively large numbers of Pacific Gulls.

The ratio for shoreline sites suggests that they may have been marginally preferred by Pacific Gulls, but the abattoir and Ralph's Bay components of it attracted slightly more Kelp Gulls, so that their proportions were similar to the overall figure. However, if the 22 shoreline sites are examined individually (see Table 4.17), it can be seen that seven had more Pacific Gulls than Kelp Gulls and they were close to parity in seven others. The remaining eight sites, in which Kelp Gulls predominated, tended also to have a higher number of birds so the combined ratio for all shoreline sites was weighted in favour of Kelp Gulls. Thus, the majority of individual sites were preferred by Pacific Gulls and these were almost all sites which supported relatively low numbers of birds. This finding is consistent with the maintenance of feeding territories by Pacific Gulls (see Section 4.3.1).

Cremorne (Site V) was not included in the ratio for combined shoreline sites, but it was a significant exception to the overall pattern. Cremorne supported quite high numbers of large gulls and was the only large site at which Pacific Gulls outnumbered Kelp Gulls. Both species loafed together on the beach and clustered around fishermen cleaning fish. Pacific Gulls were clearly dominant in this situation; they generally positioned themselves closest to the food source while Kelp Gulls tended to hang back and snap up pieces missed by Pacific Gulls. This feeding relationship differed markedly from that recorded at tips where Pacific Gulls were largely kleptoparasitic upon Kelp Gulls (see Section 4.3.3).

(b) Age structures. An alternative way to consider Kelp and Pacific Gull preferences for specific feeding sites is to examine the age structure of flocks present at the feeding sites. This approach was adopted by Monaghan (1980) who used published life table data and rates of population increase to calculate the theoretical age structure of Herring Gulls in England. The expected age structure of winter flocks was 48% adult and 52% immature (juvenile and sub-adult) birds. Monaghan compared these expected proportions with the actual values recorded at a tip and found that adults never comprised less than 87% of the total.

The population parameter values used by Monaghan for Herring Gulls are close to those which have been determined for New Zealand Kelp Gulls (see Section 3.3.7), and could also be expected to be applicable to the Kelp Gull population in Tasmania. However, one parameter which is required is the rate of population growth. The data available for the Tasmanian population are inadequate to provide a value for growth rate; it could be in the order of 25% per year (see Section 3.3.7), but cannot be specified accurately. There is little information on any population parameters for the Pacific Gull (see Section 3.2.7) so it is not possible to calculate expected age proportions for this species either.

Nonetheless, relative differences in age structure within one species can be used to compare preferences for different feeding sites. The mean percentages of adults of each species recorded at different feeding sites over the study period are presented in Table 4.19.

TABLE 4.19

Mean Percentage of Adult Kelp and Pacific Gulls Recorded at the Three Large Tips and Shoreline Sites in South-East Tasmania

Feeding Site	Proportion of Adults %	
	Kelp Gull	Pacific Gull
Hobart tip	52.2	0.0
Lauderdale tip	66.9	29.5
Margate tip	80.7	28.1
Shoreline sites	69.8	54.9

The percentage of adult Kelp Gulls was lowest at Hobart tip and highest at Margate tip, while Lauderdale tip and the shoreline sites had intermediate values. Monaghan (1980) interpreted her over-representation of adult Herring Gulls as the outcome of competition for food: all age classes sought to feed at tips but immature birds were subordinate to adults and were forced to forage more widely. Juvenile and sub-adult Kelp Gulls are also subordinate to adults at Tasmanian tips (see Section 4.3.2), so this explanation could account for the high percentage at Margate tip and perhaps also the somewhat lower percentage at Lauderdale tip. However, the low percentage at Hobart tip suggests that it was not preferred by adults, resulting in reduced intraspecific competition which would encourage proportionately more immature birds to feed there. Hobart tip had several characteristics which could be likely to make it less preferable: it was the tip most disturbed by vehicles and least often bulldozed (see Sections 4.2.1 and 4.3.1) and the furthest from water (see Section 4.1.2) and known roosts (see Section 4.2.3).

Pacific Gull age structure shows much the same trend more emphatically, since no adults were ever recorded at Hobart whereas a little over one quarter of the birds at the other two tips were adults. It is difficult to account for this pattern of age structure in terms of Monaghan's (1980) argument because we found that immature Pacific Gulls were actually dominant over the adults (see Section 4.3.2); it could be suggested that adults are forced to forage elsewhere by dominant immature birds. However, the highest proportion of adult Pacific Gulls in south-east Tasmania was at the shoreline sites where they were not subordinate (see Section 4.3.2). It thus seems likely that Pacific Gulls preferred these sites and this was supported by evidence for the defence of shoreline feeding territories by adults (see Section 4.3.1). The adults which do feed at tips may be less successful individuals which have been unable to obtain a territory on the shoreline sites.

When these age structure results are considered in conjunction with the findings for the ratios of Kelp and Pacific Gulls it is apparent that the two species differ in their preferences for feeding sites. In general, Kelp Gulls exhibit a preference for the man-made food sources provided by rubbish tips, whereas Pacific Gulls prefer the relatively natural shoreline sites.

4.3 Behaviour at Tips and Shoreline Sites

4.3.1 General behaviour patterns

(a) Shoreline sites. Table 4.20 presents the percentage of Kelp and Pacific Gulls recorded flying, swimming and standing or sitting when first sighted in the shoreline sites. Birds which were standing or sitting have been further split into categories classifying the type of substrate which they were using. The sites which attracted large concentrations of gulls (Sites D, I, J, U and V) were excluded from this analysis because of the difficulty involved in recording the activity of numerous birds simultaneously.

TABLE 4.20

Percentage of Three Types of Activity on Different Substrates for Kelp and Pacific Gulls at Shoreline Sites in South-East Tasmania

Activity	Substrate	Proportion of each Species (%)	
		Kelp Gull	Pacific Gull
Flying	-	18.0	12.7
Swimming	-	8.0	13.3
Standing or Sitting	Edge	26.7	6.6
	Rocks	18.0	11.4
	Roof	2.0	9.0
	Jetty	6.0	12.0
	Post	9.3	15.7
	Boat	12.0	19.3

Kelp Gulls were more likely to be flying than Pacific Gulls, perhaps because more Kelp Gulls were transient rather than resident (see below). Pacific Gulls were more frequently recorded swimming and were generally feeding at this time. The two species differed noticeably in their choice of substrate when they stood or sat down. Kelp Gulls were far more likely to be at the waters edge, and were also more often seen on rocks extending out from the shoreline. The other substrates (roofs of buildings; wharves and piers; mooring posts and piles; decks, cabins and masts of boats) were generally further from the bank and were more isolated. These substrates were preferred by Pacific Gulls. Fitzgerald and Coulson (1973) reported a similar pattern on a tidal river in England: Great Black-backed Gulls generally took the "best" positions from which to observe the surrounding area, while the smaller Herring and Lesser Black-backed Gulls occupied the remaining positions.

We observed some competition for these vantage points, and this appeared to be related to the defence of feeding territories. This aspect of gull behaviour has received little attention since most studies have been conducted in breeding colonies or at large feeding aggregations (such as tips). However, Drury and Smith (1968) reported that individual Herring Gulls defended shoreline feeding territories against conspecifics in autumn and winter, and Davis (1975) found that individual Herring Gulls regularly occupied the same sites at a fish dock, although these were shared with other individuals and were not defended. There is also some published evidence of year-round territoriality in Pacific Gulls (see Section 3.2.4), and regular use of sites and defence of feeding territories by Kelp Gulls (see Section 3.3.4).

Our observations suggest that Pacific Gulls occupied feeding territories singly or in pairs at some of the shoreline sites surveyed. These sites are listed in Table 4.21. They all supported only low numbers of large gulls, but at least one adult Pacific Gull was recorded there in one-third or more of the weekly surveys. Most of the territories were in bays and were thus fairly clearly delineated by topographical features. The small tidal flat in Risdon Cove (Site L) was occupied only at low tide, so the bird must have moved beyond it at other times.

TABLE 4.21

Percentage of Visits in which One or More Adult Pacific Gulls were Recorded at some Shoreline Sites in South-East Tasmania

Site	Percentage of Visits when at Least One Bird was Recorded
G	33
K	33
L	38
O	60
Q	50
S	36
T	57

Apart from the regular sighting of adults in these sites, we observed defence of the sites on several occasions. These interactions are summarized below.

i) At Howrah Beach (Site T) an adult Pacific Gull chased two juvenile Pacific Gulls plus a juvenile and adult Kelp Gull from a favoured vantage point in quick succession. One juvenile Pacific Gull and the adult Kelp Gull left the bay.

ii) A juvenile Pacific Gull landed 50 m from an adult Pacific Gull feeding on the exposed mudflat in Risdon Cove (Site L). The adult took off and flew at the juvenile which quickly left the bay.

iii) The pair of adult Pacific Gulls in Lindisfarne Bay (Site O) attacked two adult Kelp Gulls swimming near the entrance to the bay. The Kelp Gulls left the area after a brief aerial battle.

iv) A juvenile Pacific Gull landed in Lindisfarne Bay and was immediately chased out by one of the two "resident" Pacific Gulls already there.

Adult Kelp Gulls were also recorded regularly at some shoreline sites which supported low numbers of large gulls. These sites are listed in Table 4.22. Two of the sites, Self's Point (G) and Prince of Wales Bay (K) also had adult Pacific Gulls regularly (see Table 4.21), and Dru Point (C) often had 3 or 4 adult Kelp Gulls, so these sites may be examples of the regular use by a number of birds which specialize in a particular feeding locality, as reported by Davis (1975) and Fordham (1968). However, no more than two adults were seen in Rose Bay (Site P), and they were involved in interactions with the Pacific Gulls in the adjacent Lindisfarne Bay, suggesting that this was a feeding territory.

TABLE 4.22

Percentage of Visits in which One or More Adult Kelp Gulls were Recorded at Some Shoreline Sites in South-East Tasmania

Site	Percentage of Visits when at Least One Bird was Recorded
C	83
G	40
K	47
P	50

These observations of territory defence were made during the time required to count the gulls at each site. More continuous observations, ideally of individually recognizable birds, would be required to confirm the preliminary findings reported here. However, from this small sample it seems that Pacific Gulls occupy discrete shoreline sites as winter feeding territories. Kelp Gulls probably also occupy some sites, but appear to be less successful than Pacific Gulls in establishing territories.

At other feeding sites, such as rubbish tips, large tidal flats and the abattoir, where food is at least temporarily very abundant, higher numbers of gulls will congregate and individuals or pairs would be unable to defend the area. In these situations Kelp Gulls would be expected to predominate because their overall numbers are higher.

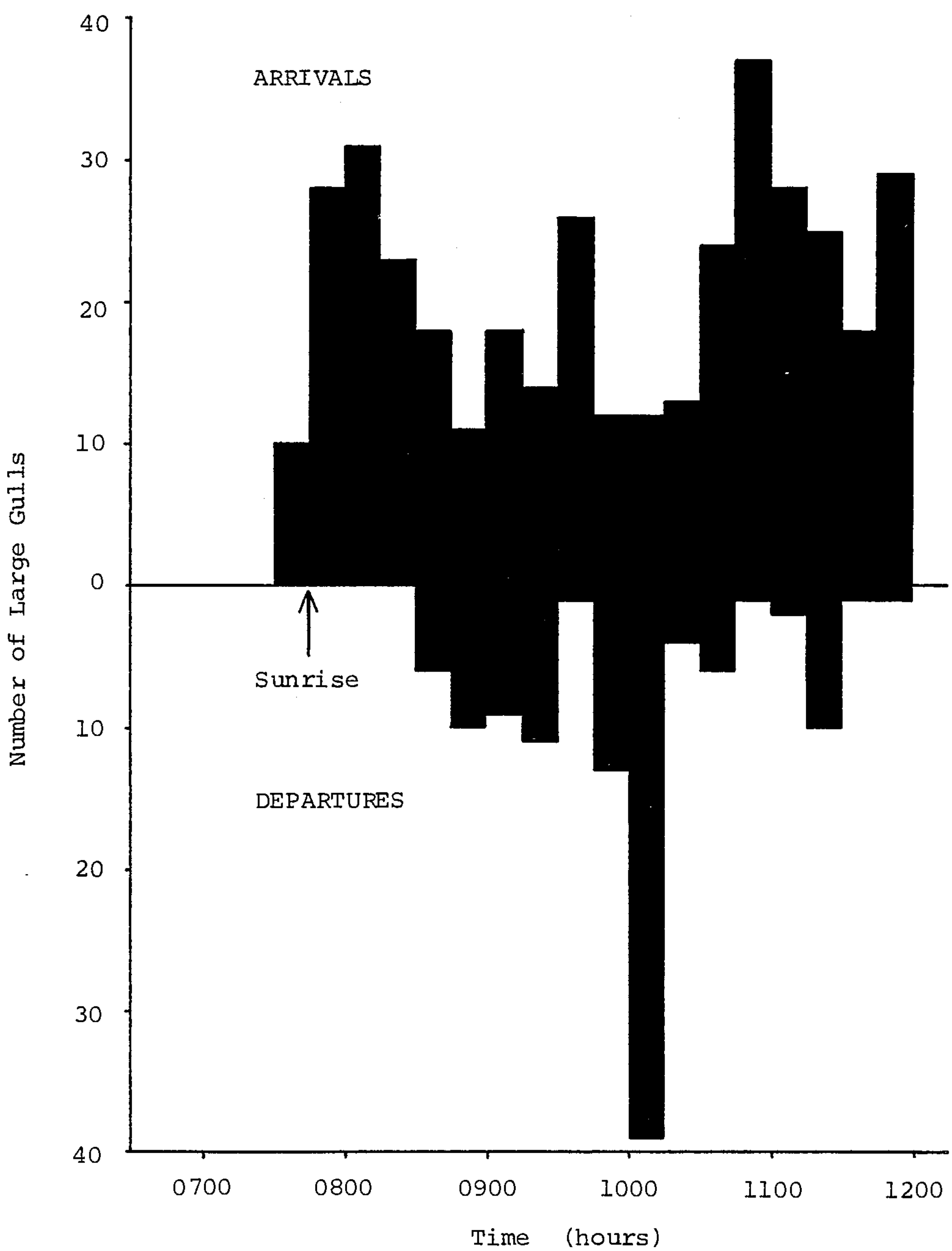
(b) Rubbish tips. Kelp and Pacific Gulls moved to and from the tips individually or in small flocks of usually only two or three birds. Disturbances in the tips which seriously alarmed the birds, such as a dog running through a loafing area, resulted in the formation of a spiralling flock of birds which often moved away from the area or eventually descended back to the tip. Spirals were composed of both Kelp and Pacific Gulls, but Pacific Gulls appeared to be less inclined to join them and often left them sooner.

The numbers of birds present at the tips increased during the morning, although there was a considerable exchange of birds throughout the day. By contrast, Monaghan (1980) found no evidence of Herring Gulls entering or leaving a tip during the part of the day when numbers remained high. The location of this tip, 17 km inland, probably encouraged the regular pattern of movement recorded by Monaghan, whereas the three large south-east tips were all close to the coast (see Table 4.1), so short excursions in and out of them were more likely. Some of the birds leaving the tips could be seen to be carrying large food items which were probably consumed later on the shoreline. Verbeek (1977b) studied Herring and Lesser Black-backed Gulls feeding at a tip close to their breeding colony during the breeding season. He found that an increased number of birds returned to the colony with food shortly after rubbish had been dumped.

The interchange of individuals is illustrated by Figure 4.11 which shows the results obtained when the birds entering and leaving Hobart tip were recorded over a five hour period on 27 June. The first arrivals were before sunrise and some birds began to depart an hour later. Virtually all the birds flew up a narrow valley to enter the tip and could thus be accurately monitored from the tip entrance. Records for both species were pooled because identification was difficult in the poor early morning light. However, the majority of birds were Kelp Gulls and it is unlikely that any more than 5% were Pacific Gulls.

FIGURE 4.11

Numbers of Large Gulls Entering and Leaving Hobart Tip Before Mid-day



During visits to Hobart, Lauderdale and Margate tip to monitor gull numbers (see Section 4.2) additional observations of general activity and feeding behaviour were made. Most observations were made using a vehicle as a hide, but some were made on foot when other people were moving around on the tip. The results of these observations are reported in this section and Sections 4.3.2 and 4.3.3.

As Kelp and Pacific Gulls arrived at the tips they generally settled near other large gulls, or less commonly among the large flocks of Silver Gulls, on the loafing areas shown in Figures 4.3 to 4.5. The only tip which had any obvious spatial segregation of Kelp and Pacific Gulls was Lauderdale, which also had the highest proportion of Pacific Gulls. Unlike Silver and Kelp Gulls, Pacific Gulls rarely used the upper loafing area. Both Kelp and Pacific Gulls loafed on the large area below the tip face, but tended to cluster in separate groups. At Lauderdale, gulls also loafed and bathed in the nearby bay, from where they could detect activity at the tip; many flew in from there to land directly on the tip face.

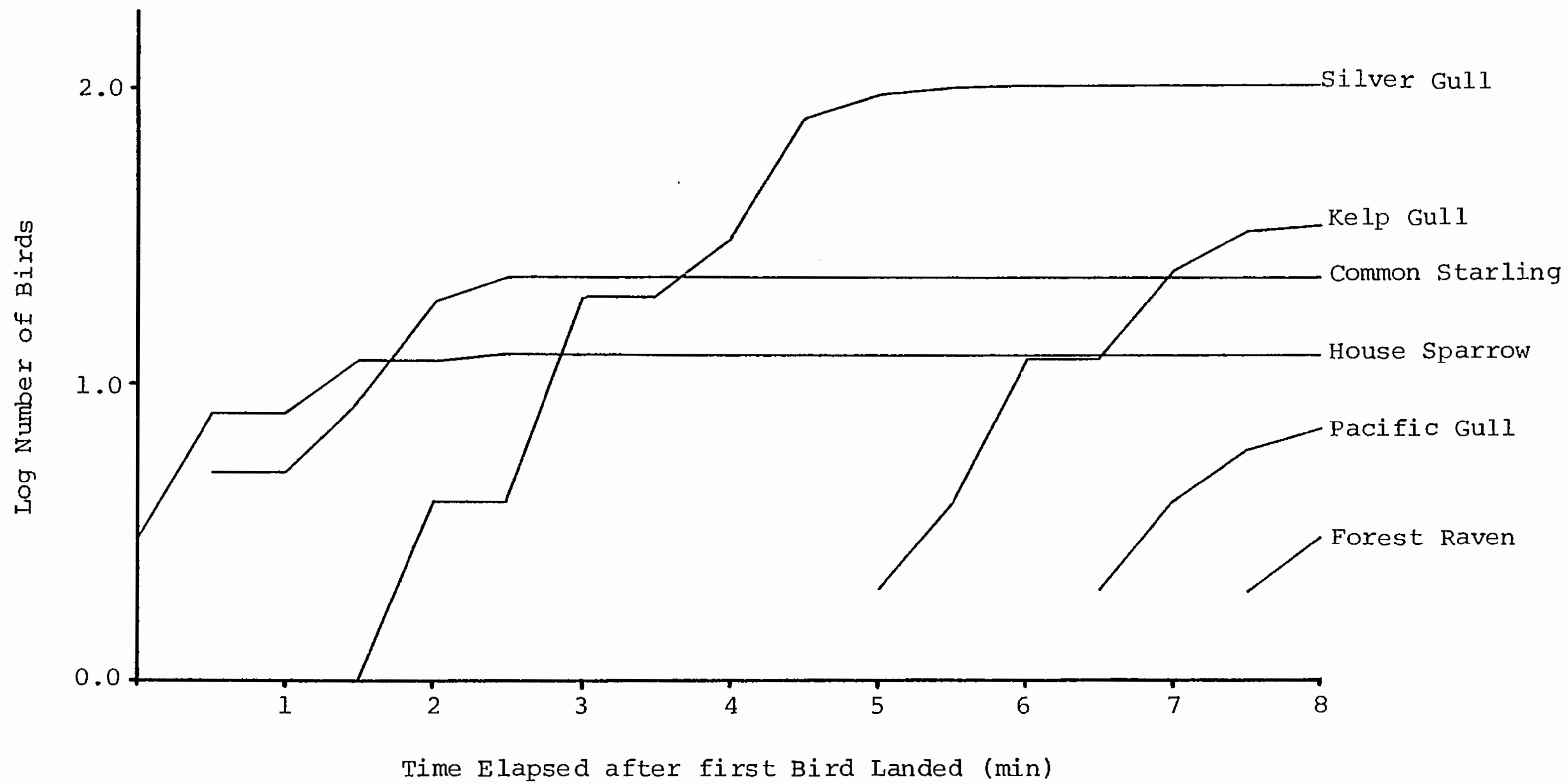
Kelp and Pacific Gulls remained on the loafing areas for most of their time at the tips and spent only a small proportion of the time actively engaged in feeding. They moved to the tip face to feed when there were no people dumping rubbish or when the bulldozer was operating. Hobart tip had a high frequency of vehicles entering the tip per hour (see Table 4.5) with the result that there were only occasional intervals in which the tip was not being used and gulls were able to feed without disturbance. In contrast, Lauderdale and Margate had roughly half the rate of vehicles arriving. Large gulls often fed there amongst recently dumped rubbish on the undisturbed face. Monaghan (1980) noted that Herring Gulls also fed during lulls in the arrival of vehicles at a tip. More frenzied feeding began when the bulldozer was operating in the tips we studied, and the same pattern has been reported in Northern Hemisphere gulls (Isenmann, 1978; Monaghan, 1980; Burger, 1981d). The operation of the bulldozer has the effect of inhibiting human movement near the tip face, but the major reason for the increase in feeding activity is most likely that bulldozing breaks open plastic garbage bags and makes more food temporarily available as suggested by Burger (1981d). Thus, the food resource available at the three tips we studied conforms to the pattern described by Monaghan (1980): the volume of food is virtually unlimited because it is continually replaced, but food is limited in time (between vehicles and during bulldozing) and space (on the tip face). Competition for food could then be predicted.

Following human disturbance on the tip face, birds gradually returned there to feed. However, it was apparent that the large gulls were slower to return than other species. We examined this phenomenon in more detail at Lauderdale and Margate tips. After some disturbance which dispersed all birds from the tip face, we recorded the number of individuals of each species as they landed on a defined section of the tip face in 30-second intervals. The majority of observations were terminated within three minutes by the arrival of another vehicle, and no large gulls landed in that time. The longest record obtained was over an eight-minute period which is shown in Figure 4.12 as a cumulative frequency semi-log plot for the six species involved. House Sparrows then Common Starlings landed first and reached their maxima within three minutes. Silver Gulls first landed after 1.5 minutes and continued to arrive at a roughly constant rate for 3 minutes, then at a declining rate up to 8 minutes. Kelp Gulls first appeared after 5 minutes. Pacific Gulls began to land 1.5 minutes later, and Forest Ravens landed last. Departures from the face were not recorded, but it was obvious that Silver Gulls soon displaced the sparrows and starlings, and the large gulls began to displace the Silver Gulls. Katzir (1981) also found that sparrows followed by starlings were the first to approach a novel food source, and the larger corvids took considerably longer. Verbeek (1977b) reported that Lesser Black-backed Gulls landed first on newly-dumped rubbish, then were soon displaced by the slightly larger Herring Gulls. Katzir (1981) suggested that the apparent reluctance of the larger species represented a form of "information parasitism" whereby they could learn about potential food sources from the behaviour of the smaller species which are forced to feed sooner by their higher metabolic demand. The smaller species can then be displaced, which appears to be typical of mixed species feeding associations (e.g. Fisler, 1977).

It is likely that the same order of landing occurred when the bulldozers began to operate, but with a greatly compressed time scale. The resultant chaotic feeding activity (and danger to the observers) made quantification impossible. However, it was notable that the more agile Silver Gulls were able to manoeuvre closer to the bulldozer than did the large gulls, as has been reported for small gull species in Northern Hemisphere tips (Isenmann, 1978; Burger and Gochfeld, 1981c).

FIGURE 4.12

Cumulative Frequency Semi-Log Plot of Numbers of Six Bird Species Landing on the Lauderdale Tip Face



4.3.2 Intraspecific and interspecific dominance at tips

To examine the nature of feeding competition, agonistic interactions amongst birds feeding on the tip face were recorded. Observations were made from the vehicle, often with the aid of 10 x 50 binoculars. We recorded all encounters which involved at least one large gull, noting the species of each of the antagonists (as well as the age class of the large gulls) and the outcome of the encounters. Agonistic interactions were initially divided into three categories:

i) displacement - one bird displaces another from the position it had been occupying;
ii) won food - one bird displaces another from a food source, or snatches an item of food away from another bird;
iii) held food - one bird successfully defended a food source or retained possession of a disputed food item in a tug-of-war.

A total of 627 decisive interactions was recorded. Of these, 50% were displacement, while the remaining 24% and 26% occurred when food was won and held respectively. All three measures were considered to be functionally similar; although displacement interactions did not involve direct competition for food they would undoubtedly influence access to food on the tip face. The data for the three categories were pooled for the purposes of analysis. The data were also pooled for observations made at the three large south-east tips. Most encounters were dyadic, but sometimes a large gull defeated a number (up to ten) of Silver Gulls simultaneously. These encounters were treated as a series of separate dyads. In addition, defence of food by presumably mated pairs was recorded once for Pacific Gulls and once for Kelp Gulls. Although they shared the food amicably they defended it separately, so their interactions could also be analysed dyadically.

(a) Intraspecific dominance. In intraspecific encounters, Kelp Gulls exhibited dominance relationships which were related to age. The data are presented in Table 4.23. Adults were dominant in 61% of decisive encounters with juveniles and in 72% of encounters with sub-adults. Sub-adult birds won slightly more than half (53%) of their encounters with juveniles. Similar age-related dominance patterns among Herring Gulls feeding at tips have been reported by Monaghan (1980) and Burger (1981d).

TABLE 4.23

Number of Wins and Losses in Agonistic Encounters Between Kelp Gulls at South-East Tasmanian Tips

LOSERS	WINNERS		
	Juvenile	Sub-adult	Adult
Juvenile	•	19	60
Sub-adult	17	•	33
Adult	38	13	•

In contrast, the low values given in Table 4.24 for Pacific Gulls suggested that older birds were subordinate to younger birds in agonistic encounters. This result could have been interpreted as an artifact of the low number of interactions observed. For comparison, observations were also made at Launceston tip. These observations were made over a one-hour period on 11 June, using the same techniques described above except that the observer was on foot because the birds seemed to be habituated to human movement near the tip face, and were fairly approachable. A total of 56 decisive encounters was recorded. The results, given in Table 4.25, confirmed the trends observed in the smaller south-east sample. Adults were dominant in less than half (43%) of their encounters with juveniles and won even fewer (30%) encounters with sub-adults. Sub-adults won only 20% of their encounters with juveniles. In interpreting these unusual results it is clear that adults are not competitively inferior to younger Pacific Gulls in general. Adults are larger (see Section 3.2.2), can defend feeding territories successfully against younger birds (see Section 4.3.1) and are dominant in agonistic encounters over food at natural sites. Adults won 10 of the 11 encounters observed with juveniles. The apparent superiority of younger birds at tips can best be explained by their adoption of a kleptoparasitic feeding strategy which is discussed in the following section (Section 4.3.3).

TABLE 4.24

Number of Wins and Losses in Agonistic Encounters between Pacific Gulls at South-East Tasmanian Tips

LOSERS	WINNERS		
	Juvenile	Sub-Adult	Adult
Juvenile	·	1	2
Sub-adult	3	·	1
Adult	7	2	·

TABLE 4.25

Number of Wins and Losses in Agonistic Encounters between Pacific Gulls at Launceston Tip

LOSERS	WINNERS		
	First Year	Immature	Adult
First Year	·	1	9
Immature	4	·	9
Adult	12	21	·

(b) Interspecific dominance. The large gulls were involved in inter-specific encounters with Silver Gulls and Forest Ravens in the three south-east tips. The success of each age class of Kelp Gulls in these encounters is given in Table 4.26. There were only 21 encounters with Forest Ravens so it may be unwise to generalize from these results: juveniles and adults won the majority of their encounters, but sub-adults won only one-third of theirs. Dominance relationships with Silver Gulls were quite clearcut since Kelp Gulls of all ages won almost all of the encounters.

TABLE 4.26

Percentage of Decisive Agonistic Encounters won by Kelp Gulls Against Forest Ravens and Silver Gulls

	Kelp Gulls		
	Juvenile	Sub-adult	Adult
Forest Raven	63% (8)[a]	33% (6)	86% (7)
Silver Gull	98% (46)	100% (16)	99% (68)

a - Number of encounters in parentheses

Table 4.27 shows the equivalent results for Pacific Gulls. Juveniles were completely dominant over Forest Ravens and were involved in encounters with them fairly frequently. No decisive encounters were observed between older Pacific Gulls and Forest Ravens. Pacific Gulls of all ages were completely dominant over Silver Gulls.

TABLE 4.27

Percentage of Decisive Agonistic Encounters Won by Pacific Gulls Against Forest Ravens and Silver Gulls

	Pacific Gulls		
	Juvenile	Sub-Adult	Adult
Forest Raven	100% (17)[a]	- (0)	- (0)
Silver Gull	100% (38)	100% (7)	100% (5)

a - Number of encounters in parentheses

Overall, these findings for the large gulls conform to a pattern of increased dominance with increased body size as suggested by Katzir (1981). The Silver Gull is the smallest of the four species and the least successful in behavioural encounters. Burger (1981d) obtained a similar result in a study of feeding competition between Herring Gulls and Laughing Gulls at a rubbish tip: the much smaller Laughing Gulls failed to win any encounters with Herring Gulls. Forest Ravens are intermediate in size, weighing about 550 g (Barker, pers. comm., 1982), and were comparatively more successful against Kelp Gulls while being totally subordinate to the Pacific Gull which is the largest species (see Sections 3.2.2 and 3.3.2).

In encounters between Kelp and Pacific Gulls the larger species was also dominant. Table 4.28 sets out the percentage of encounters won by Pacific Gulls against Kelp Gulls. Each age class of Pacific Gulls won at least two-thirds of encounters against each Kelp Gull age class. Similarly, Verbeek (1977b) found that Herring Gulls were more aggressive, as measured by the number of pecks at other birds, than were the slightly smaller Lesser Black-backed Gulls feeding with them at a tip. Although the numbers in several cells of Table 4.28 are low, there is a noticeable trend of increasing interspecific dominance in relation to age in both species such that older Pacific Gulls win relatively more encounters. This result is in accord with the age-related intraspecific dominance relationships recorded in Kelp Gulls, but reverses the trend recorded in intraspecific dominance amongst Pacific Gulls. The end result was that in encounters with large gulls of any particular age class, Pacific Gulls were more successful against Kelp Gulls than against other Pacific Gulls.

TABLE 4.28

Percentage of Decisive Agonistic Encounters Won by Pacific Gulls against Kelp Gulls

Kelp Gulls	Pacific Gulls		
	Juvenile	Sub-adult	Adult
Juvenile	95% (20)[a]	100% (13)	100% (6)
Sub-adult	80% (5)	75% (4)	100% (3)
Adult	74% (23)	67% (6)	81% (27)

a - Number of encounters in parentheses

4.3.3 Feeding strategies at tips

In order to determine the relative feeding efficiencies of Kelp and Pacific Gulls we recorded foraging behaviour using a focal sampling technique. Observations were made from a vehicle which was positioned as close as possible to the tip face. At Margate tip the observations were made mainly during lulls between vehicles. At Lauderdale tip we observed while the bulldozer was operating and in the period after it had stopped and before the next vehicles arrived. It was found difficult to make observations at Hobart tip; only four birds were sampled so they have been excluded from the data presented in this section. We endeavoured to sample equal numbers of Kelp and Pacific Gulls and equal numbers of each age class; in practice, sub-adult Kelp Gulls and sub-adult and adult Pacific Gulls were under-represented (see Table 4.29).

Individual birds which had alighted on the tip face were observed for a period of two minutes, but if they moved out of sight sooner the observation was terminated. The period of observation was timed with a stopwatch. Although it was difficult to distinguish individual birds within one age/species category, we tried to ensure that individuals were not sampled twice during one session of observation. Birds with obvious injury (e.g. loss of foot, blind in one eye) were excluded from the sample. Within each sampling period the number of the following behaviours were recorded:

i) pecking at food or the substrate;
ii) swallowing food items;
iii) attacks on other birds by pecking or chasing;
iv) avoidance or retreat from other birds.

The identity of the other birds involved was also recorded.

Table 4.29 sets out the rates at which these acts were performed by the three age classes of Kelp and Pacific Gulls. The rates of behaviour were highly variable and in all cases the standard deviations were close to or higher than the mean values obtained. The levels of activity we observed ranged from birds which pecked and swallowed food without interruption to others which stood motionless or wandered around for the duration of the observation period.

TABLE 4.29

Means of Four Types of Foraging Activity on the Tip Face by each Age Class of Kelp and Pacific Gulls at Three Large Tips in South-East Tasmania

Age Class	Species	N	Frequency per Minute			
			Pecks	Swallows	Attack	Avoid
Juvenile	Kelp	24	7.77 } **	4.93	0.58	1.23
	Pacific	25	3.80 }	2.53	1.29	0.15
Sub-adult	Kelp	21	3.09	1.34	0.53	1.08
	Pacific	11	4.57	3.24	0.60	0.36
Adult	Kelp	27	5.37	3.31	1.25	0.58
	Pacific	8	4.07	2.67	0.68	0.00
Totals	Kelp	72	5.51	3.28	0.82	0.93 } *
	Pacific	44	4.04	2.73	1.01	0.18 }

* $P < 0.05$ ** $P < 0.01$

A comparison by t-tests of the means obtained for pecking rate revealed no intraspecific (between age class) differences and only one interspecific (within age class) difference which was statistically significant: juvenile Kelp Gulls pecked at food twice as often as did Pacific Gulls of the same age Class. Pecking rates give a rough measure of feeding effort, but it is also necessary to consider feeding success which was measured by the rate at which food items were swallowed. There were no statistically significant differences in swallowing rates between species (within age classes) or between age classes or totals of each species. By comparison, interspecific and intraspecific differences have been reported in feeding rates of Northern Hemisphere gulls feeding on tips. Using the same measure of swallows per minute, Verbeek (1977b) found that Herring Gulls had higher feeding success than Lesser Black-backed Gulls; Verbeek (1977c) and Burger (1981d) reported that adult Herring Gulls had higher feeding success than younger conspecifics.

To examine the relationship between feeding effort (pecks) and feeding success (swallows) Burger (1981d) calculated the percentage of pecks which were successful to yield an index of feeding efficiency. In her study of

Herring Gulls feeding at tips she found that the feeding efficiency of adults was superior to that of younger birds. Feeding efficiency indices were calculated for each age class of Kelp and Pacific Gulls as the means of the indices for individual birds. Birds which did not peck at all were excluded from the sample. The results are presented in Table 4.30. There were no significant differences (using t-tests) between any intraspecific or interspecific (within age class) combinations of means. Overall, the feeding efficiency of both Kelp and Pacific Gulls was 56%.

TABLE 4.30

Mean Percentage of Pecks in which Food was Swallowed by Each Age Class of Kelp and Pacific Gulls

Species	Age Class			
	Juvenile	Sub-adult	Adult	Totals
Kelp Gull	64.5%	46.3%	52.8%	55.6%
Pacific Gull	59.9%	56.6%	41.5%	55.9%

However, this approach to analysing feeding efficiency is limited by the implicit assumption that the food items ingested in each swallow are more-or-less equivalent in nutritional value, or at least that items of different value are ingested randomly by each age/species category. It became apparent that this was not the case during the course of this study: Pacific Gulls, particularly juveniles, appeared to concentrate on the larger food items. In an attempt to document this phenomenon more fully in the later stages of the study, we distinguished between four types of food source:

i) small isolated items which can be readily swallowed (e.g. a small potato chip);

ii) large single items which can be carried and swallowed whole, albeit often with some difficulty (e.g. a fish head);

iii) large amorphous items which cannot be carried and have to be eaten in a series of separate pecks (e.g. spaghetti);

iv) large single items which are too large to carry or swallow and have to be eaten in separate pecks (e.g. a leg of lamb).

Due to the limitations of time we were not able to accumulate sufficient observations to allow any quantitative analysis of the types of food items eaten. However, some generalizations can be made. Small type (i) items were scattered irregularly and unpredictably over the tip face; they were utilized by Silver Gulls and the large gulls, but juvenile Kelp Gulls in particular often adopted a strategy of foraging methodically within a small area, which seemed well suited to locating these items. This is supported by the high pecking rate of juvenile Kelp Gulls (see Table 4.29). Possession of type (i) items was sometimes disputed by more than one bird, but the items were readily swallowed and the first bird to locate one generally managed to consume it. Williams (1977) estimated that Kelp Gulls have a daily energy requirement of about 880 kJ in mid-winter. Since a small potato chip, for example, yields only about 25 kJ, a large number of type (i) items would have to be consumed to meet this demand.

Type (ii) items, by comparison, would make a major contribution to a large gull's daily energy budget. Any large gulls which located a type (ii) item would endeavour to swallow it, but would usually be subjected to harassment by other birds. The outcomes of these encounters have been examined in Section 4.3.2. Pacific Gulls, particularly juveniles, often adopted a feeding strategy which enabled them to utilize type (ii) items very effectively. They alighted on the face and remained stationary or moved around slowly while watching other birds feeding; when another bird located a type (ii) item the Pacific Gull would charge at it, often giving the charge call (see Section 3.2.4) and frequently managing to steal the item. Variations of this strategy also occurred: taking advantage of the energy subsidy available on windy days, Pacific Gulls often hovered above the face and dived at birds with food, and on most days a number of Pacific Gulls stayed mainly at the periphery of the face making occasional forays onto it or accosting birds as they left carrying food. The latter alternative also appeared to be the major strategy adopted by Forest Ravens.

The different feeding strategies used by Kelp and Pacific Gulls were not clearly reflected in the data obtained for the rates of attack and avoidance given in Table 4.29. The rates were highly variable, and there were no significant differences (using t-tests) between the means for each age class (within species) or between species (within age classes). However, the full sample of all Kelp Gulls had a significantly higher avoidance rate than all Pacific Gulls. When the rates of attack and avoidance are examined together a clearer pattern emerges. Table 4.31 presents percentage values of the mean number of attacks divided by the sum of the means for attack and avoidance for each age/species category. A value of 50% represents an equal rate of attack and avoidance; 100% indicates that agonistic activity was entirely made up of attacks. It was not possible to calculate the score for each individual sampled and then determine the mean for each group, because very few birds exhibited both attack and avoidance in the short sampling period and would thus have had either the maximum or minimum values. This treatment of the data also did not permit any tests of statistical significance, but the trends are clear. Overall, Kelp Gulls scored much lower than Pacific Gulls: juvenile and sub-adult Kelp Gulls scored less than 50% whereas adult Pacific Gulls scored 100%. Thus, the relative time allocations to attack and avoidance were consistent with the outcomes of such agonistic behaviour as determined in the previous section (Section 4.3.2).

TABLE 4.31

Mean Scores for Attack Rate as a Percentage of the Sum of Avoidance and Attack Rates for Each Age Class of Kelp and Pacific Gulls

Species	Age Class			
	Juvenile	Sub-adult	Adult	Total
Kelp Gull	32.0%	32.9%	69.8%	46.9%
Pacific Gull	89.6%	62.5%	100.0%	84.9%

Kleptoparasitism is a feeding strategy commonly used by gulls (Brockman and Barnard, 1979), and has been recorded in both the Pacific Gull (see Section 3.2.4) and the Kelp Gull (see Section 3.3.4). Both species were observed to steal food at the tips as well as searching methodically for their own food. However, only Pacific Gulls were predominantly kleptoparasitic. There have been some studies of kleptoparasitism among Northern Hemisphere gulls feeding at tips. Burger and Gochfeld (1981c) found that in absolute terms most food was stolen by Herring Gulls which were the second largest and the most numerous of the two large gull species present at the tip; Great Black-backed Gulls, the largest species, were very rarely the victims of kleptoparasitism. Verbeek (1979) concluded that

Great Black-backed Gulls at a tip fed exclusively by kleptoparasitism of the smaller Lesser Black-backed and Herring Gulls. He also found that size was not the only important factor, because Lesser Black-backed Gulls were more agile and far more kleptoparasitic than the slightly larger Herring Gulls (Verbeek, 1977a,b).

These studies analysed mainly aerial chases after a bird had flown from the tip face carrying food, unlike the present study which concentrated on the strategies displayed on the tip face. The focal sampling method which we adopted required that observations were terminated when birds flew from the face. To gain some information on aerial chases we studied them at Lauderdale tip in August. In order to observe the progress of a chase it was necessary to leave the vehicle; this was not compatible with the methods used for recording dominance and foraging on the tip face, so chases were observed over only three days. We recorded the species which first took off with the food item, the number of birds of each species involved in the chase and, where possible, the species which eventually won the food. In practice it was difficult to determine the outcome of chases and many appeared to break up spontaneously. We recorded 23 chases which involved large gulls and the results are given in Table 4.32. Despite the small sample some trends are apparent. Whereas Kelp Gulls seemed to concentrate on Silver Gulls as victims in preference to Pacific Gulls, Pacific Gulls chased Silver Gulls and Kelp Gulls almost equally. Both large gulls chased conspecifics; the victims and chasers were of all three age classes in the Kelp Gulls, but only juvenile Pacific Gulls were recorded as victims and most chasers were also juveniles. When the relative numbers of Kelp and Pacific Gulls present at Lauderdale tip are taken into account, it is clear that Pacific Gulls are over-represented as chasers, indicating that it is the species which is most kleptoparasitic in the air as well as on the ground. Verbeek (1977b) obtained similar results for Herring and Lesser Black-backed Gulls at a tip, and suggested that the more kleptoparasitic Lesser Black-backed Gull was inefficient at locating food and were thus largely dependent on the Herring Gulls to find food which the Lesser Black-backed Gulls could then steal. Verbeek further suggested that Lesser Black-backed Gulls were also numerically dependent, in that the numbers of the host species (Herring Gulls) limited the smaller number of kleptoparasites which could exploit them. The predominance of Kelp Gulls at the large south-east tips (see Section 4.2) is consistent with this model. However, a similar relationship cannot exist in Tasmania because Pacific Gulls also feed at tips in the north of the state where Kelp Gulls are absent (see Section 4.1).

TABLE 4.32

Number and Identity of Birds Involved in Aerial Chases

Bird First with Food	Mean No. of Birds in August	Birds Involved in Chase			
		Silver Gull	Forest Raven	Kelp Gull	Pacific Gull
Silver Gull	685	26	2	15	6
Forest Raven	88	0	2	0	1
Kelp Gull	283	0	5	7	8
Pacific Gull	43	2	3	3	15
Totals		28	12	25	30

To examine the feeding strategies adopted by Pacific Gulls in the absence of Kelp Gulls, we carried out observations on two consecutive mornings in June at Launceston tip using the same focal sampling technique outlined above. The sample consisted of 30 birds and the three age classes were represented approximately equally. The results are presented in Table 4.33. These figures can be compared with the rates of each activity for Pacific Gulls in the south-east (Table 4.29). The statistical significance of the difference between the means of all the birds in each sample was determined by t-tests. Pacific Gulls at Launceston had almost double the pecking rate of their conspecifics in the south-east ($P < 0.02$), but also had a significantly lower feeding efficiency of only 26.7% ($P < 0.01$), with the result that the swallowing rates of the two populations were not significantly different. There was no difference in avoidance rates, but Pacific Gulls in the south-east had a higher rate of attacks ($P < 0.05$).

TABLE 4.33

Means of Four Types of Foraging Activity on the Tip Face by Each Age Class of Pacific Gulls at Launceston Tip

Age Class	N	Frequency per Minute			
		Pecks	Swallows	Attack	Avoid
First Year	10	11.81	3.20	0.35	0.54
Immature	11	4.49	1.09	0.72	0.00
Adult	9	8.08	2.77	0.26	0.36
Total	30	8.01	2.30	0.46	0.29

These findings suggest that Pacific Gulls in south-east Tasmania have responded to the presence of Kelp Gulls at tips by increased emphasis on kleptoparasitic strategies. Verbeek (1977b) and Burger and Gochfeld (1981c) concluded that kleptoparasitism on the ground and in aerial chases was a productive strategy for large gulls since the items of food were large, chases were usually brief and the chances of winning the food were good. Detailed study of food item size, energy expenditure, probability of success and metabolic requirements of the birds would be necessary to compare the overall efficiency of kleptoparasitic strategies with other strategies such as the more methodical searching used to a large extent by Kelp Gulls. It would also be instructive to know if Kelp Gulls have modified their feeding methods in response to kleptoparasitism by Pacific Gulls, as has been reported in other host/kleptoparasite associations (e.g. Taylor, 1979; Barnard and Stephens, 1981), but there are no data on feeding activity available for allopatric populations of Kelp Gulls.

At the level of analysis permitted by this study it can be seen that Kelp and Pacific Gulls ingest food items at a comparable rate. There is no evidence that either species is disadvantaged when feeding together at tips; the suites of strategies employed by Kelp and Pacific Gulls appear to enable both species to utilize this additional food resource.

5 Management of Large Gulls in Tasmania

5. Management of Large Gulls in Tasmania

Since it was first recorded in Australia, the Kelp Gull has become an established breeding resident, exhibiting a steady growth in population size and in the formation of new colonies. As such it has become the second species of large gull in the avifauna of Australia.

The ecological implications of this additional species are examined in this chapter. It synthesizes the experiences with population explosions of large gulls in the Northern Hemisphere, which were reviewed in Chapter 2, with the biological information currently available for the Kelp Gull and the endemic Pacific Gull compiled in Chapter 3, as well as the findings from our field study of the feeding behaviour of the two species in Tasmania as reported in Chapter 4. In addition, it examines the techniques of gull management which are available, ranging from direct control of gull populations to modification of their habitats, with particular reference to techniques of rubbish tip management. Finally, this chapter proposes specific action for the conservation and management of the Kelp Gull and Pacific Gull in Tasmania.

5.1 Ecological Impact of the Kelp Gull in Tasmania

5.1.1 The course of colonization by the Kelp Gull

The uncertainty about the origin of the Kelp Gulls which colonized Australia has been discussed in Chapter 3. Early reports suggested that they may have been accidentally introduced through escapes from a zoo, but this could not adequately account for the early sightings. The explanation most consistent with available morphometric data and the known distribution of the Kelp Gull is that the colonizers flew to Australia from New Zealand, possibly assisted by following shipping across the Tasman Sea. However, the earliest (originally misidentified) record of the Kelp Gull in Western Australia in 1924 considerably pre-dated those of the incipient New South Wales colony. It suggests that Kelp Gulls had reached Australia from time to time in the past and, if they were sighted, were probably assumed to be Pacific Gulls.

In a number of respects the arrival of the Kelp Gull parallels the colonization of Australia by another widespread species, the Cattle Egret, *Ardeola ibis*. The probable course of colonization has been summarized by Hewitt (1960) and Hindwood (1971). A flock which was deliberately released in northern Australia in 1933 soon disappeared and probably did not survive, then the next record was of hundreds of birds 15 years later, suggesting that there had been natural immigration. There was also some evidence that the species had occurred naturally in northern Australia prior to their liberation. Since then, the Cattle Egret has rapidly established breeding colonies and extended its range to many parts of Australia. It is generally accepted that the success of the Cattle Egret in Australia can be attributed to its adaptation to a hitherto vacant ecological niche: it is primarily a predator of soil invertebrates which have been disturbed by buffalo and cattle introduced to Australia. The timing of the Kelp Gull's arrival and subsequent spread in Australia can be examined in similar terms.

The broad niche for a large coastal scavenger had been previously occupied by the Pacific Gull, and it is likely that competition from this endemic resident would have prevented the Kelp Gull from becoming established. However, the Pacific Gull underwent local extinction on the Queensland and New South Wales coast early this century, and the niche it had previously occupied thus became vacant. It was probably the absence of large gulls in New South Wales which drew attention to the arrival of Kelp Gulls, while isolated individuals were likely to be overlooked in areas which still supported Pacific Gulls.

In support of this explanation, it is significant that the Kelp Gulls in New South Wales appear to be exclusively coastal feeders and are not utilizing any additional food source which may have been introduced by human activity. By contrast, Kelp Gulls feed at tips where they occur sympatrically with Pacific Gulls in Tasmania and Western Australia (see Section 3.3.5). Once the first Australian colony had been established, further extension of range and the formation of new colonies would have been facilitated. The availability of additional man-made food sources may have enabled the Kelp Gull to colonize new areas, particularly south-east Tasmania, by minimizing competition with the Pacific Gull. This contention is substantiated by the Kelp Gull's readiness to utilize non-traditional food sources in New Zealand, by the early reports of concentrations of birds in the vicinity of abattoirs and a rubbish tip, and by the significance of tips as feeding sites for the present population in south-east Tasmania. Although this interpretation is apparently contradicted by the observations of Pacific Gulls also feeding at tips, that behaviour has been reported only in publications since 1967 (see Section 3.3.5). Sharland (pers. comm., 1981) stated that Pacific Gulls did not feed at tips prior to the arrival of Kelp Gulls in south-east Tasmania because refuse at tips was then burnt, a practice which would obviously have discouraged gulls (see Section 5.2.2). We have been unable to determine when burning was formally discontinued at tips in south-east Tasmania, but it is apparent that the changed methods would have made a new, abundant food source available to both species. Historic population data are lacking for the Pacific Gull and it is impossible to gauge its response to the additional food in numerical terms, but the Kelp Gull has undergone a well-documented population increase in south-east Tasmania, as it has in New Zealand, in response to additional food of human origin.

In these terms, the colonization of Australia by the Kelp Gull can be summarized as a two-stage process: initial colonization took place in areas from which the Pacific Gull had disappeared, then subsequent expansion into areas still occupied by Pacific Gulls was facilitated by the availability of additional food, particularly at tips.

This interpretation is necessarily conjectural and several alternatives could be proposed. For example, chance factors must play a large part in the process of colonization; the first colony could have become established in that particular time and place through a coincidence of chance events such as the presence of birds of both sexes, and low mortality and limited dispersal for several years. In addition, the unknown factors which caused the decline of Pacific Gulls on the eastern coast of Australia could have still been operating when the Kelp Gull arrived and, although not having such an impact on Kelp Gulls, may have been sufficient to account for the low growth rate of the New South Wales colonies.

Whether or not this view of the role of man-made food sources in the past is accepted, it is clear that rubbish tips are a significant food source now. We recorded a total of about 440 Kelp Gulls at the three large tips on an average winter day, representing 43% of the known population in south-east Tasmania. There is little doubt that the extra food available at tips is contributing to their population increase in the region, as has been reported for Kelp Gulls in New Zealand and several species of large gulls in the Northern Hemisphere.

5.1.2 General implications of an increased Kelp Gull population

The implications of a continuing increase in Tasmania's population of Kelp Gulls are examined in this section. It is assumed that the population is well below the carrying capacity of the Tasmanian environment at present, and will continue to grow unless some control measures are implemented.

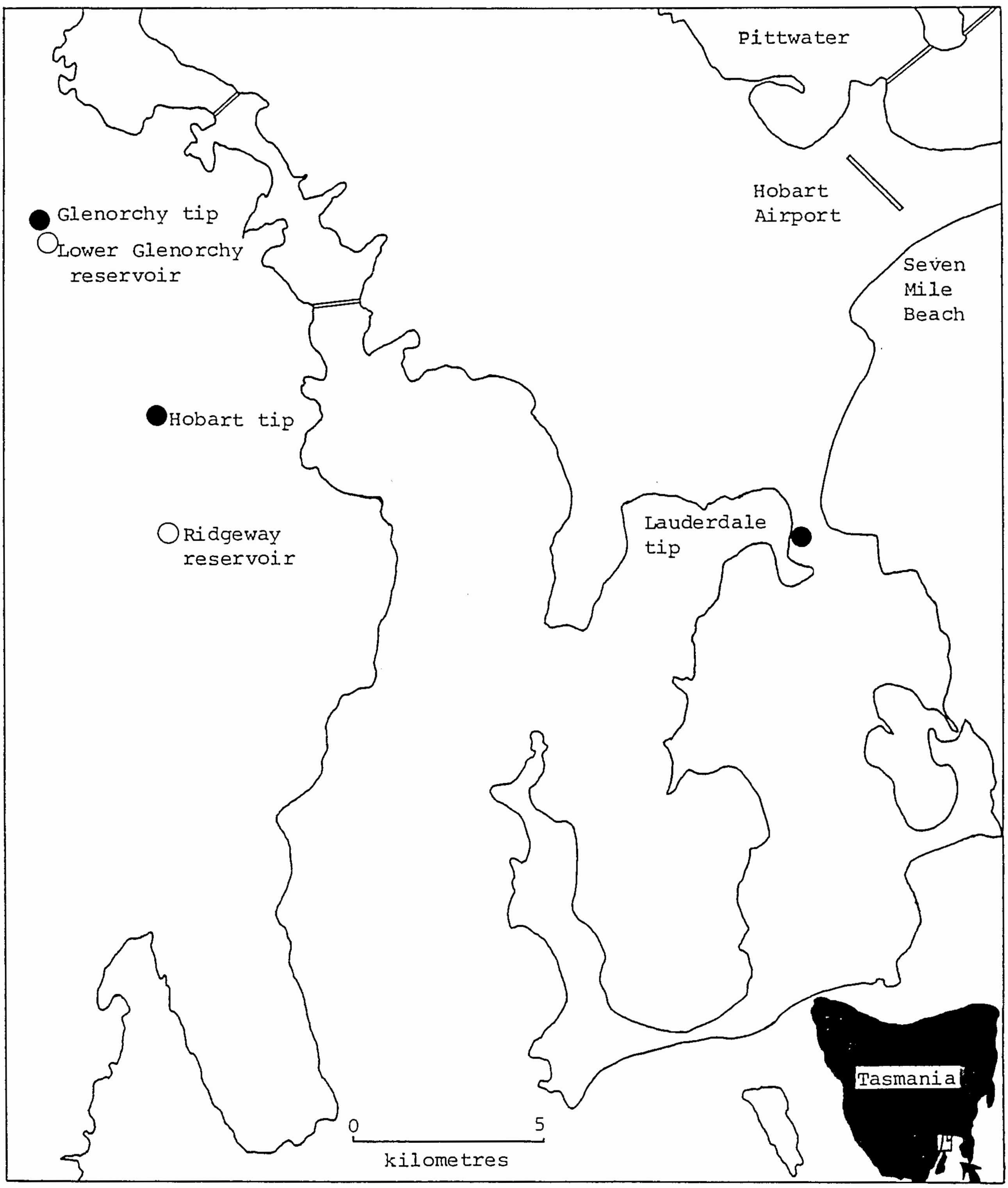
(a) Inland feeding and breeding. The Tasmanian environment is similar to New Zealand in many respects, particularly in having damp soil which facilitates feeding on soil organisms. There are no apparent constraints to Kelp Gulls extending their range to feed inland in Tasmania. They would be expected to feed mainly on farmland by "following the plough" and foraging in rain-soaked paddocks, but could also scavenge carcases of domestic stock and possibly attack weakened animals (see Section 3.3.5).

Inland breeding is also a common phenomenon in New Zealand and South America (see Section 3.3.6) and the large number of highland lakes in Tasmania offer suitable breeding habitat. Rooftop nesting is apparently not common in New Zealand but could become a problem as has been experienced with large gulls in Britain (see Section 2.3.4).

(b) Water pollution. Pollution of water supplies by large gulls has been reported in the Northern Hemisphere (see Section 2.3.3). In south-east Tasmania the potential public health problems are already apparent. The Glenorchy tip is adjacent to a reservoir (see Figure 5.1) and elevated bacterial levels have been recorded in the water of the reservoir. Gulls have been successfully discouraged from using the area by firing blanks at the tip and the reservoir (Hunt, pers. comm., 1981). Similarly, large flocks of Kelp Gulls which have fed at Hobart tip regularly stop and bathe in Ridgeway reservoir (Harris, pers. comm., 1981), which is on the flight line to their roosts in the south Derwent Estuary (see Figure 5.1). This reservoir serves the City of Hobart and the Municipality of Kingston; the supply has been monitored closely, and to date the chlorination treatment has been adequate to maintain water quality (Lister, pers. comm., 1981).

FIGURE 5.1

Location of Three Large Tips and Potential Public Health and Bird Strike Risks in South-East Tasmania



(c) Bird strikes. Kelp Gulls have not yet been reported in collisions with aircraft in Australia as they have in New Zealand (see Section 3.3.8), but the probability of a collision will increase as the population grows. The relatively large body size of the Kelp Gull could also be expected to result in more significant damage than is caused by Silver Gulls which are frequently struck (see Section 3.1.3). The proximity of Lauderdale tip to Hobart Airport (see Figure 5.1) has caused some concern and the management of the tip has been examined for possible ways of reducing its attraction to gulls (Newman, pers. comm., 1981). At present, Kelp Gulls fly along Seven Mile Beach at right angles to the runway and also roost in Pittwater in low numbers. If Pittwater becomes a more significant roost site in future, the greater amount of traffic to and from the tip would increase the risk of collision, particularly in the morning and evening.

(d) Competition with other species. The Kelp Gull has the potential to compete with other species for food and for breeding sites. These two forms of competition are examined in turn.

(i) Feeding. At present the Kelp Gull feeds in mixed species aggregations with Silver Gulls and Pacific Gulls on the shoreline, and with these species plus other more terrestrial species (e.g., ravens and starlings) at rubbish tips. Overt competition for items of food occurs in both situations, and the analysis of these interactions in Sections 4.3.1 and 4.3.2 indicates that the Kelp Gull is competitively superior to the other species, with the exception of the Pacific Gull. The degree of competition with the Pacific Gull is discussed in more detail in the following section (Section 5.1.3). Increased competition with the other species could be predicted to cause a decline in their populations, and this would be most likely to occur in Silver Gulls which are similar to Kelp Gulls in habitat preferences. Overt competition with other shoreline-feeding birds (e.g. oystercatchers) has been reported in South Africa and New Zealand (see Section 3.3.4) and could develop in Tasmania. Kelp Gulls are also likely to have a less obvious impact by causing changes in the abundance and composition of the littoral fauna. Finally, if Kelp Gulls begin to feed inland they would probably come into competition with Silver Gulls again, as well as specialized terrestrial feeders such as egrets and the Australian Magpie (*Gymnorhina tibicen*).

(ii) Breeding. In New Zealand the Kelp Gull has had a serious impact on the nesting of other species firstly by selecting new nest sites in areas previously occupied by the other species, and secondly by predation of the eggs, chicks or adults of other species. The species most affected are waders and terns (Bell, pers. comm., 1981). Similarly, Kelp Gulls have been reported to steal eggs of the Roseate Terns in South Africa and have been nominated as a potential threat to Little Terns in New South Wales (see Section 3.3.8). Terns also seem to be the species most likely to be affected in Tasmania and there is some evidence that this has begun to occur: Crested Terns, *Sterna bergii*, have not bred since 1978/79 on Green Island, the site of the largest Kelp Gull colony, although the terns have been inconsistent in breeding on the island (Fletcher *et al.*, 1980).

5.1.3 Competition with Pacific Gulls

As with other species, potential competition with Pacific Gulls may take two forms.

(a) Feeding. The published data for the diets of Kelp and Pacific Gulls suggest that the two species are very similar in feeding requirements (see Sections 3.2.4 and 3.3.4), and competition for food has been predicted by Ford (1964) and Simpson (1972). However, the findings from our field study indicated that although both Kelp and Pacific Gulls fed at rubbish tips and shoreline sites in winter, there is a degree of resource partitioning. In general, Kelp Gulls preferred tips and Pacific Gulls preferred shoreline sites. When Pacific Gulls did feed at tips they responded to the presence of Kelp Gulls by adopting a largely kleptoparasitic strategy; there was no evidence that their feeding efficiency was reduced by competition with Kelp Gulls or that it was inferior to the efficiency of the Kelp Gull (see Chapter 4).

Analysis of a sample of freshly regurgitated pellets collected around Kelp and Pacific Gull nests (see Appendix 1) indicated that resource partitioning was maintained during the breeding season. The most noticeable differences in diet were that the major proportion of Kelp Gull pellets contained refuse whereas refuse was detected in only one Pacific Gull pellet; by contrast, a much higher proportion of Pacific Gull pellets contained fragments of crab, and a wider range of species was taken.

(b) Breeding. The three large Kelp Gull colonies in south-east Tasmania are on islands shared with Pacific Gull colonies. Calaby (cited by Green,

1977) visited Green Island in the 1976/77 season and recorded approximately 125 pairs of Kelp Gulls, concluding that this species appeared to be superseding the Pacific Gull which then had only a few pairs. Similarly, Fletcher *et al.* (1980) reported considerable interaction between the two species on Green and Visscher Islands, and predicted that the local population of Pacific Gulls could decline in consequence.

The colonies on Green Island have been under study for six seasons. Fletcher *et al.* (1980) estimated that there were 100 Kelp Gull nests in 1976/77 (compared with Calaby's estimate of 125) with an addition of about 30 nests per year so that the count for 1980/81 was 239 nests. This trend continued in the following season when Coulson *et al.* (in prep.) recorded 275 nests.

In contrast to this smooth growth pattern, the records of Pacific Gull nests fluctuated. Fletcher *et al.* (1980) reported counts ranging from a maximum of 17 in 1979/80 to only 4 the following season. In 1981/82 Coulson *et al.* (in prep.) recorded the highest total of 27 nests. There are two aspects of the counting methods used which could account for this irregular pattern. Firstly, Ferns and Mudge (1981) reported that direct nest counts of Herring and Lesser Black-backed Gull nests were under-estimated by 17% on average, and pointed out that accuracy could be improved with increased effort either by using more people or spending more time. The effort expended on Kelp Gull nest counts varied from year to year, and some nests were likely to have been missed. Secondly, the nests of Kelp and Pacific Gulls can generally be distinguished (see Sections 3.2.6 and 3.3.7), but it is probable that some errors were made. If Pacific Gull nests were misidentified there would be a relatively small addition to the Kelp Gull total and a significant reduction in the total of Pacific Gull nests. When these limitations are taken into account it is not possible to determine any long term trend in the numbers of Pacific Gulls nesting with the growing Kelp Gull colony.

Behavioural interactions between Kelp and Pacific Gulls have been studied by Coulson *et al.* (in prep.) from a hide on Green Island. The two species nested close together, but no overt territorial behaviour was observed between the two species although intraspecific disputes were common. No Pacific Gull eggs were lost to other gulls, whereas some Kelp Gull eggs were taken by Silver Gulls. When mixed flocks of large gulls flew about after disturbance individual Kelp Gulls occasionally made brief and harmless chases after Pacific Gulls, as they also did when other Kelp Gulls were close in front of them; the reverse was not seen. Pacific Gulls thus appeared to be able to select and maintain nest sites despite the large number of Kelp Gulls present. The only situation in which Kelp Gulls may have been directly reducing the reproductive success of Pacific Gulls was when young Pacific Gulls took to the water following human disturbance and were often attacked by adult Kelp Gulls. The effects of these attacks were uncertain, although no deaths could be directly attributed to them.

5.2 Possible Control Measures

If any of the potential environmental effects (outlined in Section 5.1.2) of an increasing Kelp Gull population are realized, it may be deemed necessary to instigate control measures. A large variety of direct methods have been employed in attempts to control gulls. An alternative approach to control is modification of the gulls' habitat, of which rubbish tips form an important part.

5.2.1 *Direct control*

Procedures used directly against gulls are of two main types: those used to disperse gulls from problem areas such as airfields, and those aimed at actually reducing the population of gulls. Since Silver, Kelp and Pacific Gulls are all protected species in Tasmania, any population reduction would have to be carried out by the National Parks and Wildlife Service or by other bodies acting under licence from the Service.

(a) Dispersal methods. There have been numerous methods used in efforts to scare gulls away from an area without actually harming them (Bridgman, 1969; Brough, 1969; Thomas, 1972; Van Tets *et al.*, 1977; Solman, 1978). Many of these dispersal methods have involved the use of visual displays, including elaborate scarecrows, trained or dummy falcons and dead gulls staked out in distorted positions. Sound effects have also been used, either in the form of firearms, shell crackers and other noise machines or as a broadcast of the recorded distress calls of the species in question.

However, shifting the birds by these means requires much human effort, is extremely difficult if they are nesting in the vicinity, and is at best only a temporary measure anyway. Since gulls habituate to high noise levels and human activity around airports, it is not surprising to find that they also quickly become habituated to sound and visual displays intended as dispersal mechanisms, although the firing of blanks has apparently been successful so far in excluding gulls from Glenorchy tip (see Section 5.1.2). The use of dead birds and distress calls appears to have had the greatest success, but gulls habituated even to these techniques. Coulson and Monaghan (1978) found that attempting to deter Herring Gulls from nesting on rooftops by broadcasting the Herring Gull alarm call was actually counter-productive, since it served only to scatter the nesting birds over the town and thereby facilitated the increase and spread of rooftop nesting gulls by providing more groups to attract potential recruits.

Various other forms of bird repellents have been trialled. Van Tets *et al.* (1977) reported that thin metal wires strung 2 m apart over ponding areas at Sydney Airport were a very effective means of keeping roosting gulls away at night, but had little effect on gulls foraging during the daytime. Wires 1 m apart failed to prevent gulls from nesting at colonies near Devonport and Wynyard Airports. Electrified wires may be used to keep birds from roosting in small, restricted locations (Van Tets *et al.*, 1977) while Jósefik (1972) had some success in laboratory tests with multipoint electrodes which he proposed would be used in association with a "prop" to signal the presence of the electric system to the birds.

(b) Population reduction. Thomas (1972) provides an extensive review of methods for the reduction of gull populations. Gulls are most accessible in the egg stage and numerous forms of control have been directed against eggs. Organized collection of eggs and young, which may incorporate the removal of nests or the substitution of dummy eggs, has been attempted as a control measure, but must be repeated frequently because the gulls will relay. Treatment of eggs to prevent hatching without breaking them has advantages in that gulls will continue incubation and delay relaying. Methods described by Thomas (1972) are pricking, injecting with formalin, shaking, spraying or dipping with an oil emulsion and the use of embryonicides such as Sudan Black B.

As shown in Section 2.2.1, egg removal by traditional egg collectors did limit some gull populations. However, there are two main disadvantages of control measures directed against eggs. Firstly, the parents remain and so immediate problems such as interference with other breeding species, or presence on airfields or in towns are not solved. Secondly, the longevity of large gulls and their late age of maturity mean that these methods must be carried out over many years if the gull population is to be significantly reduced (Thomas, 1972; Coulson and Monaghan, 1978). Herring Gulls have an average breeding life of 15 years, breeding for the first time when aged 4-5 years (Coulson and Monaghan, 1978). Similar figures are likely to apply for Pacific and Kelp Gulls (see Sections 3.2.7 and 3.3.7).

Consequently, Monaghan and Coulson (1977) considered that clearing areas completely of adult gulls was a better method to use if it was desired to control gulls nesting in towns. A review of methods for eliminating fledged gulls is provided by Thomas (1972). On a small scale, birds can be selectively removed by rocket or cannon netting, trapping, catching at night or shooting. Over large regions, the use of poison such as strychnine or narcotic such as alpha chloralose is more efficient, but both agents are non-selective and the risk of ingestion by non-target species needs to be carefully considered.

Bread baits spread with beef dripping and alpha chloralose were used to kill Kelp Gulls which were nesting in the vicinity of an airfield at Napier, New Zealand, and causing a serious hazard to aircraft (Caithness, 1968). Narcotic baits were also used to cull breeding Herring Gulls which had become a problem on the Isle of May in Scotland (see Section 2.3.1). Follow-up studies at this colony (Chabrzyk and Coulson, 1976; Duncan, 1978) have provided some insight into the mechanism of recruitment into colonies (discussed in Section 2.1.2) which has important implications for the management of gull colonies. Firstly, the finding of considerable immigration from other colonies means that even poisoning over four or five years to allow for maturing birds may not have any lasting effect on local population numbers. Secondly, greater understanding of the relationship between nest density and recruitment suggests that, to be effective, gull control must reduce the density of breeding birds below the minimum level which attracts recruits (about two pairs per 100 m^2 for the Herring Gulls on the Isle of May). If some gulls are to be retained, then encouraging them to nest at high densities (greater than 10 pairs per 100 m^2) should help to prevent growth of the colony.

5.2.2 Habitat modification

In appropriate cases, alteration of habitat so that it is no longer attractive to gulls can be the most effective way of dealing with a gull problem. This approach has the added advantage of not entailing trauma to the gulls.

(a) Airports. Airports are often very attractive to gulls, offering ideal resting and feeding areas. In addition, airports tend to be situated near water because of the requirement of large areas of flat, cheap land with clear approaches, and are often incidentally near to facilities such as rubbish tips or pig farms which are undesirable in heavily populated areas (Caithness, 1968; Solman, 1978). Control methods involving removal of birds are likely to be ineffective because other birds will soon move in to utilize the resource, and as discussed above, there is as yet no reliable method for the dispersal of birds from airports. Habitat modification offers a solution which is particularly attractive because it can be permanent. Van Tets *et al.* (1977) and Solman (1978) outline a number of ways in which the environment at airports can be controlled to remove sources of food, shelter and water which attract gulls.

Sometimes it may also be desirable to alter gull habitats outside the airport, so that the number of birds in the area around the airport is reduced. This could involve alteration to breeding habitats, or to feeding habitats, especially rubbish tips.

(b) Breeding habitats. Modification of breeding habitats by the clearing of vegetation and debris prevented Silver Gulls from rearing their chicks on Egg Island near Devonport Airport, and so solved the problem which had formerly resulted in the closure of the airport when thousands of fledglings from the colony would congregate on the runway and refuse to move out of the way of aircraft (Van Tets *et al.*, 1977).

Such extreme manipulation of breeding habitat may be intolerable in other circumstances, particularly where less common birds are nesting in the same area as a pest species. However, interspecific differences in nest site preferences may be able to be exploited in some cases (e.g. Thomas, 1972).

(c) Rubbish tips. Rubbish tips have been shown to be a very important part of the habitat for many gull populations contributing to population increases both in the Northern Hemisphere (see Section 2.2.2) and in Tasmania. Since the use of rubbish tips by gulls is a central theme in this thesis, the management of solid waste disposal in Tasmania is briefly discussed here.

(i) Current waste disposal practice. Disposal of wastes in Tasmania is regulated by the Department of the Environment, which grants licences to municipal councils to operate rubbish tips under specified conditions. These conditions relate to the site, method and operation of the tips. Municipal councils are responsible for site acquisition and maintenance, and for collection of garbage where applicable. The predominant method of solid waste disposal used in Tasmania is landfilling, which may be further described as surface spreading, trench, or sanitary landfilling.

As the name suggests, surface spreading involves the dumping of rubbish onto the land surface, often onto a slope which may be partially excavated. There tends to be very little maintenance of these sites, and the rubbish remains exposed. In trench landfilling, rubbish is tipped into a steep sided trench which helps to contain the rubbish and can be more effectively maintained. Covering of the rubbish by soil may be carried out periodically depending on the licence requirement which is determined largely according to the size of the tip and the financial capacity of the municipality (Bastias, pers. comm., 1981). Both of these methods are confined to small tips, and are comparatively cheap to operate. More recently established tips tend to be trench form rather than surface spreading.

Sanitary landfill is the prescribed method for all large rubbish tips, and is euphemistically described by Berry and Horton (1974):

> *Sanitary landfill is a nuisance-free method of refuse disposal characterized by competent and continuing engineering planning and control. Sanitary landfills do not produce ground and surface pollution, nor is there any burning of any kind. Refuse is compacted and covered each day with six inches (15 cm) or more of earth cover material. The earth cover is also compacted to provide a tight seal that will do the following:*
>
> *1) prevent flies from laying eggs on the refuse or rodents from invading the fill;*
> *2) seal in odours;*
> *3) prevent rainwater from entering the fill;*
> *4) minimize the blowing and scattering of refuse;*
> *5) prevent the emergence of adult flies that have been bred in the refuse; and*
> *6) provide a surface on which trucks can operate.*

The sanitary landfill operations surveyed in Tasmania varied considerably in the extent to which they met that description. For example, we twice observed early morning burning of rubbish at Margate tip. Burning, which had been a common feature of rubbish tips, is generally proscribed by the Department of the Environment regulations, although an exemption was granted to the Spring Bay Municipality for the Triabunna/Orford tip (Department of the Environment, 1980).

(ii) Waste disposal options. In the light of our findings and those published by other authors, possible changes in waste disposal methods can be discussed with regard to their effect on gulls.

Alternatives which could be considered in a Tasmanian context include closed incineration, composting, recycling, energy recovery, or a combination of these methods with landfilling. A change from open dumping to closed incineration of garbage at a site in England caused large congregations of gulls to disperse (Hickling, 1969), and Nisbet (1978) noted that the conversion of some large dumps to resource recovery facilities had made food unavailable to gulls. However, while economic factors are obviously not the only criteria to be considered in planning waste disposal projects (e.g. Sobral *et al.*, 1981), the cost of any of these alternatives is so much higher than the traditional landfilling operation that they are extremely unlikely to be implemented to any great extent in Tasmania. Consequently, realistic management options have to be considered within the constraints of the landfill method.

One change which would probably be desirable from the public health point of view would be the upgrading of all rubbish tips to sanitary landfill sites. The daily covering of refuse was considered by Kihlman and Larsson (1974) to have contributed to a decrease in the population of Herring Gulls in Sweden, by decreasing the amount of food available. Nisbet (1978) felt that the change from open dumps to sanitary landfills probably did not reduce the amount of garbage available to gulls, but limited their access to it and might sharpen competition between adults and immatures. Burger (1981d) found that the operation of a sanitary landfill could also affect interspecific competition and favour one species over another. However, such action is most unlikely because of the comparatively high costs of operation of a sanitary landfill. The majority of tip sites in Tasmania serve less than 2500 people (Department of the Environment, 1975), whereas Maunsell and partners (1981) found that the cost of implementing sanitary landfilling techniques based on daily covering of wastes was too great for communities with under about 5000 people. Moreover, the conversion of tips in Tasmania would have little effect on gulls because by far the majority of gulls was observed at tips which already use the sanitary landfill method.

Another option available while retaining the existing methods of waste disposal is the location of the sites. The location of Lauderdale tip near to the Hobart Airport has the potential to cause bird-strike problems, as discussed in Section 5.1.2. Similar situations involving Kelp Gulls in New Zealand (Caithness, 1968) and Silver Gulls in Sydney (Van Tets *et al.*, 1977) caused serious problems which were ameliorated by the closing of the tip, or by tipping and covering refuse after sunset.

No significant correlation was found between the number of gulls using tips in Tasmania and the distance of the tip from water, but there was some indication that Pacific Gulls were more reluctant to travel inland to feed at a tip than were Kelp Gulls (see Section 4.1.2). Since Kelp Gulls overseas are known to move long distances inland (see Section 3.3.4), the location of tips away from water could selectively favour Kelp Gulls over Pacific Gulls.

5.3 Conclusions

The aim of this study was to examine the significance of rubbish tips as a winter food resource for the Kelp and Pacific Gull in Tasmania. Rubbish tips have been found to be an important food source for large gulls in the Northern Hemisphere, and a number of environmental problems have arisen as a consequence of the resulting increase in gull populations. We found that tips are an important food source for Kelp Gulls in Tasmania and are probably contributing to their population growth. Pacific Gulls also utilize tips but to a lesser extent, and prefer more natural shoreline sites. There was no evidence that Pacific Gulls were competitively inferior to Kelp Gulls at tips or on shoreline sites. There was also no clear evidence that the Pacific Gull has suffered a population decline since the arrival of the Kelp Gull in south-east Tasmania.

We expect that the Kelp Gull population will continue its relatively rapid rate of growth, at least in the near future. This growth, if unchecked, could have wide environmental consequences, but we see no reason to introduce controls at this stage. We believe that more attention should be paid to the potential ecological problems which have arisen in other countries, such as public health risks and competition with smaller bird species.

At present, the Pacific Gull appears to be secure in Tasmania, but further study will be essential to achieve the conservation and management of the Kelp

Gull and Pacific Gull. This is the responsibility of the National Parks and Wildlife Service of Tasmania, which should encourage and co-ordinate research in two areas.

Firstly, a comprehensive breeding study is needed to examine the relationships between Kelp and Pacific Gulls fully in mixed colonies. Such a study should focus on behavioural interactions and comparative reproductive success. Although Green Island has been most studied and is readily accessible from Hobart, it may be more productive to examine another, probably newer, Kelp Gull colony (e.g. Lachlan Island) which has more even proportions of the two species and would thus yield more data on Pacific Gull reproduction and interspecific interactions. Additionally, attention should be given to the impact of human disturbance on the relative reproductive success of the two species.

Secondly, a long-term programme of population monitoring is required to detect changes in density of either Kelp or Pacific Gulls. Our study has provided base-line data for the two species in Tasmania. Future monitoring need not be conducted annually, but should be carried out thoroughly at intervals and at a number of levels. Individual winter feeding territories in urban areas could be readily monitored by local ornithologists. Numbers of gulls utilizing rubbish tips are also easily monitored: continuing records of gull numbers at existing tips should be compiled, and it would then also be possible to assess the effects of fortuitous changes such as the imminent relocation of Launceston tip. The winter census of large gulls conducted by the Bird Observers Association of Tasmania should be continued, with care taken to standardize the methodology and areas covered. The census should also be extended to the north coast to establish the present population levels of Pacific Gulls so that the effect of any future extension of range of the Kelp Gull into this region can be accurately determined. Winter censuses should be complemented by effective monitoring of breeding colonies, particularly in the south-east, to detect changes of status of the Kelp Gull and the Pacific Gull in Tasmania.

6
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6. REFERENCES

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Appendix

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APPENDIX 1

Analysis of Pellets Regurgitated by Kelp and Pacific Gulls During the Breeding Season

Pellets were collected weekly from near nests belonging to known species on Green Island from November to December 1981. Pellets were broken apart for analysis of contents, and examined under a dissecting microscope when necessary. Reference collections of crabs and chitons were established to facilitate the identification of the fragments found in pellets. In compiling this table below, each food item was scored as present or absent. The percentage figures therefore do not necessarily represent the importance of each item in the diet. For example, no distinction is made between evidence of one or several crabs of a particular species in a pellet. However, the table does enable the diets of Kelp and Pacific Gulls to be compared. The percentage of pellets containing each group of food items is shown in bold type.

Food Item	Percentage of Pellets Containing the Food Item	
	Kelp Gull	Pacific Gull
Gastropods:	**0**	**9.3**
Subninella undulata	0	9.3
Cephalopods:	**6.8**	**7.0**
Squid beak	6.8	4.7
Cuttle bone	0	2.3
Chitons:	**36.4**	**28.0**
Amaurochiton glaucus	27.3	16.3
Sypharochiton	25.0	16.3
Crabs:	**11.4**	**55.8**
Petrolisthes elongatus	6.8	7.0
Philyra laevis	0	4.7
Ovalipes australiensis	2.3	25.6
Paragrapsus gaimardi	0	18.6
Cancer novaezelandiae	0	4.7
Cyclograpsus granulosus	2.3	4.7
Unidentified	2.3	4.7

APPENDIX 1 (Continued ...)

Food Item	Percentage of Pellets Containing the Food Item	
	Kelp Gull	Pacific Gull
Echinoderms	4.5	9.3
Fish	34.1	46.5
Mammal	2.3	0
Plant	25.0	0
Refuse:	54.5	2.3
Glass	11.4	0
Fibre	15.9	2.3
String	4.5	0
Plastic	27.3	0
Paper	6.8	0
Bones	40.9	0
Silver paper	11.4	0
Other	15.9	0
Gravel	15.9	0
Other: millipede	0	2.3
Number of pellets in sample	44	43